THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

PROCEEDINGS

FOR

1906

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PROCEEDINGS OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 22.

PRESENTED FEBRUARY 28TH, 1906.

THE SUBSTRUCTURE OF THE HOUSATONIC RIVER BRIDGE AT NAUGATUCK JUNCTION, CONN.

BY CAMILLE MAZEAU,* C. E., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEO. W. TILLSON, NOAH CUMMINGS, EDWARD M. LAW, JOHN G. THEBAN, ELMORE F. AUSTEN, MARTIN GAY, HORACE J. HOWE AND THE AUTHOR.

The New York Division of the New York, New Haven & Hartford Railroad has been for a number of years a four-track line, the first section of which was built back in the 80's and continued down to the present time. Of the more important bridges, only the one over the Norwalk River and the one over the Pequonnock River were four-tracked, when in 1903 it was decided to rebuild the bridges over the Mianus, Saugatuck, and Housatonic Rivers on which a double-track service was still maintained, thus completing the last links necessary for a four-track system from New York to New Haven.

It is not the purpose of this paper to dwell on the Mianus and the Saugatuck River bridges, other than to allude to the fact that at these latter places temporary structures were built, about 100 ft. north of the main line, to take care of the whole traffic while the old bridges were being taken down and the new ones rebuilt. These are timber trestles of pile and framed bent construction, averaging 35 ft. in height, braced and bolted. Temporary drawbridges of the jack-knife pattern provide for the river traffic.

* Assistant Engineer. New York, New Haven and Hartford Railroad Co.

At the Housatonic River, however, this was not done. At the site of the bridge the water is about 35 ft. in depth, with a difference of 6 ft. between high and low water. There is a tidal current up stream, and a down-stream current of about six miles per hour maximum. In the winter the ice becomes very threatening; during the winter of 1903-1904 it was piled at the west bank some 40 ft. high. Nor was it unusual during a severe winter for the water to freeze so hard about the old fender piles at low tide as to pull them out as the tide rose. These and other considerations led to the decision to proceed at once with the new piers under the old bridge, thus avoiding a temporary structure and the disturbance of traffic.

Pipe soundings and test piles furnished the data for a preliminary estimate. Hydraulic borings were also made, followed by diamond drilling into the solid rock; the cores were brought and kept for record.

The location of the new piers and the resulting span lengths of the new bridge were influenced by the location of the old piers, which would have to be retained until traffic could be diverted from the old bridge to the new structure. It was desired to use a uniform length for the fixed spans, but for the westerly span this had to be abandoned, because the wash borings to the rock ledge at the proposed location of (see Plate I) Pier 1 indicated a very undesirable surface, considering the fact that the new pier came on the low side of the slope and only 30 ft. from the old pier. It was, therefore, placed on the higher part of the slope to the west. The span lengths, as finally adopted, are as follows:

Span 1	149 ft. 9 in.	
" 2	110 ft.	
" 3	34 ft. 8 in.	
" 4	110 ft.	channel span.
" 5	222 ft. 8 in.	
" 6	222 ft. 6 in.	
" 7	222 ft. 9 in.	
Total	1 072 ft. 4 in.	

The new four-track structure provides for two parallel double-track bridges placed 36 ft. 9 in. c.-c., and so located in respect to the

PLATE I.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MAZEAU ON HOUSATONIC RIVER
BRIDGE AT NAUGATUCK JUNCTION.

FIG. 1.—NEW AND OLD PIERS; STYLE OF MASONRY; ICE BREAKERS; PROXIMITY OF NEW TO THE OLD PIERS.

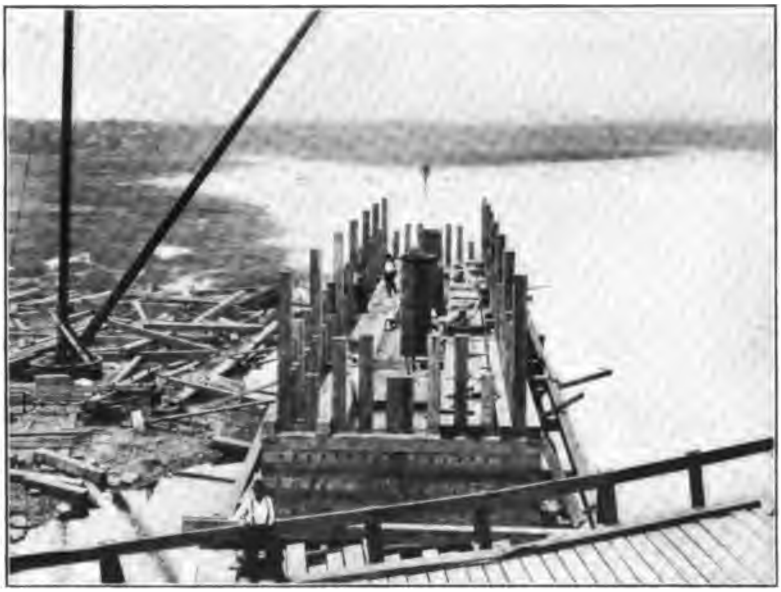


FIG. 2.—CAISSON CONSTRUCTION.

old bridge that the southerly half can be erected without disturbing traffic. When the southerly portion is completed it is purposed to turn the traffic over the same, remove the old brige, and erect upon its location the northerly portion of the new structure.

The loads for which the steel work was designed are those of the New York, New Haven and Hartford Railroad Company's specification of 1904, and give the following end reactions:

West Abutment..	705 000 lb. per shoe—fixed load, live load, and impact allowance.
Pier 1..........	705 000 lb. truss, fixed load, live load, and impact allowance. 304 000 lb. girder, fixed load, live load, and impact allowance.
Pier 2..........	304 000 lb. girder, fixed load, live load, and impact allowance. 800 000 lb. Scherzer, fixed load, live load, and impact allowance.
Pier 3...........	1 206 000 lb. Scherzer, fixed load, live load, and impact allowance.
Piers 4, 5, 6, and East Abutment..	1 042 000 lb., fixed load, live load, and impact allowance.

The East Abutment on shore was the first work commenced. The excavations were in cofferdam, and continued down to gravel. As this was done directly in front of the old abutment, one part of which was on a timber crib resting on the mud, and the remainder on short piles, care was necessary to prevent movement. Concrete was used in the footing, and the sheet piling and the lower lines of bracing were left in the work. Bonding was then effected between the old and the new masonry.

The West Abutment is in the water, and clear of the old masonry. The river mud was excavated from inside a cofferdam down to the rock ledge which varies from 2 ft. to 25 ft. below high water. The surface was blasted for founding as it was smooth and sloping in places. Rubble masonry was used in this footing.

The masonry for the abutments is random-ranged with rubble backing. The bridge seats and coping are of ashlar.

Pier 1 was established 26 ft. west of the old Pier 1. Wash bor-

ings indicated an uneven rock ledge bottom, varying from 20 to 40 ft. below high water, and sloping towards the south.

The depth and character of the old pier foundations could not be ascertained by either records or soundings.

As there was but 13 ft. clearance between the old pier and the new work, great caution was necessary during the operations. A 12-in. sheet pile cofferdam was driven, braced above and below low water mark, and dredging carried on inside. The ledge surface as cleaned was rough, and sufficiently undulating to prevent the pier from slipping, without doweling or other preparation.

Concrete laying proceeded through the water to within 8 ft. of low water mark. As the work progressed $\frac{7}{8}$-in. square steel rods, 15 to 18 ft. long, were placed in alternate longitudinal and diagonal layers, and continued in height until they extended from end to end of the footing. The pier was heavily rip-rapped, and the sheet piling left in place, but sawed off below water.

Before the new pier had been completed a crack developed in the old pier, but there was no other sign of settlement.

Pier 5 was also founded by the open cofferdam method. It was established 55 ft. east of the east rest pier of the old draw. The rock ledge was 50 ft. below high water, underlying a bed of coarse sand and fine gravel. The bottom of the pier was fixed below the plane of scour. It was dredged and a 6-in. sheet piling cofferdam was driven and braced.

Concrete was laid through the water to within 8 ft. of low water mark. After the completion of the masonry the footing and the surrounding area were thoroughly rip-rapped to prevent scour. The sheet piling was then pulled.

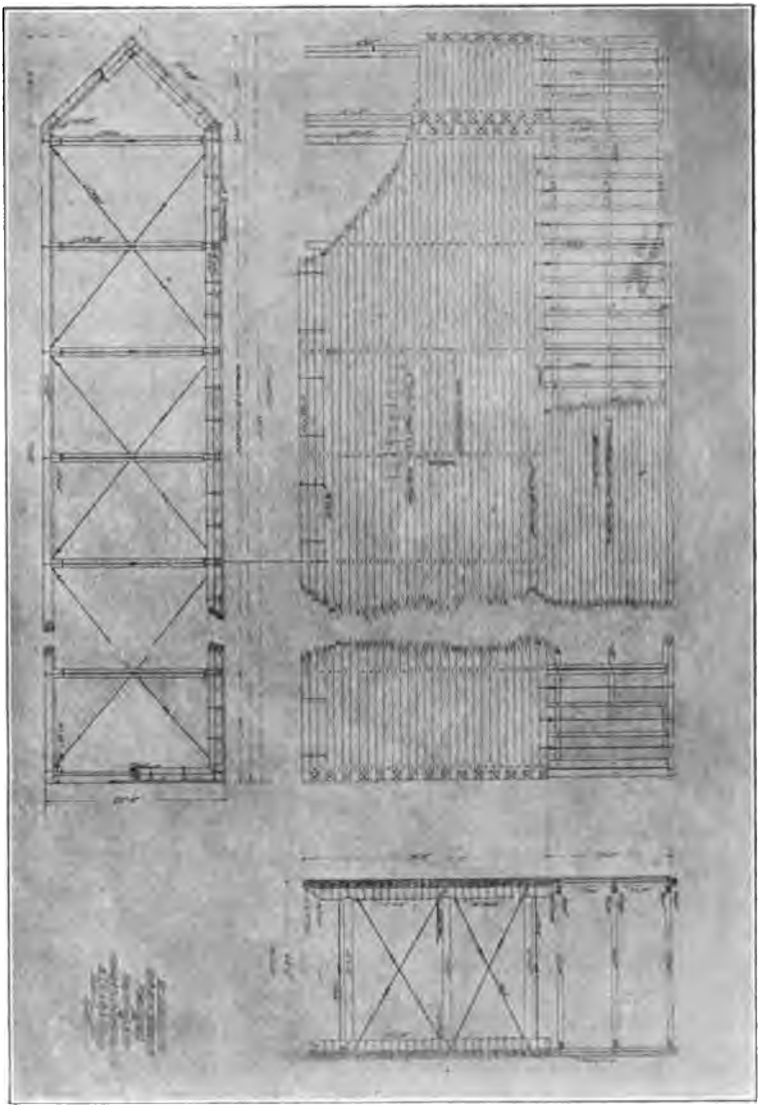
Piers 2 and 3 are 34 ft. 8 in. c.-c., and are located between the old Pier 1 and the west rest pier of the old draw, Pier 3 being 72 ft. west of the latter, which was founded on piles and had been known to move. (See Plate I.)

The wash borings indicated a fairly level rock ledge surface 53 ft. below high water, underlying a bed of gravel.

The river bottom of silt and sand was dredged to the gravel 45 to 48 ft. below high water.

The piers were founded by the open crib method. These are essentially timber structures of 12-in. by 12-in. material, close laid,

PLATE II.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MAZEAU ON HOUSATONIC RIVER
BRIDGE AT NAUGATUCK JUNCTION.



PLAN OF CRIB.

and braced internally. They have no bottoms, and are designed to remain in the work. A removable cofferdam of lighter construction is made fast by hook bolts.

Sinking was effected by loading with rail on top of the cofferdam, and so distributed as to keep them vertical. When down, rip-rap enough was deposited to seal the cribs at the bottom.

Concrete was laid inside of the cribs through 48 ft. of water to within 8 ft. of low water mark.

The footings were rip-rapped as high as the original river bed elevation.

Piers 4 and 6 were founded by the pneumatic process. Timber caissons were used similar to those at Hartford, Conn. They are designed to leave as little timber as possible in the work. The walls of the working chamber consist of two thicknesses of 12-in. timber, and the decks of three thicknesses. Above the deck the walls have but a single thickness, and upon the deck there is a crib 5 ft. deep. The launching height is 14 ft., which afloat draws 9 ft. of water. (See Plates I, II and III.)

The cofferdam section is continued while the caisson is sinking, as also the removable cofferdam.

At Pier 6 the wash borings indicated rock ledge 52 ft. below high water on which were strata of silt, sand, and gravel. The location was dredged 10 ft. below low water mark in order to float the caisson freely until ready for sinking.

Sinking was effected by trenching and the loosened material in the chamber removed by blow pipe.

The caisson was founded 52 ft. below high water, and the chamber filled with concrete.

The adjoining pier, 50 ft. to the east, founded on piles which had previously moved, was not disturbed by the sinking.

Borings at Pier 4 indicated rock 67 ft. below high water at the north and south ends, and 84 ft. at the center, with a layer of gravel 63 ft. below high water underlying silt and sand.

The pier was located in the channel under the old draw span between the pivot pier and the west rest pier, 38 ft. east of the latter. (See Plate I.)

The caisson was founded 62 ft. below high water, and the chamber filled with concrete.

During the sinking of the caisson the old piers showed signs of settlement, which, however, did not become serious.

The maximum air pressure was 31 lb.; the workmen experienced several cases of the bends, but of short duration.

All concrete laid through the water consisted of one part cement, two parts sand, and four parts gravel, and concrete laid above water of one part cement, three parts sand, and five parts gravel.

The masonry of the piers is of ashlar face, with concrete backing (see Plate I), laid alternate header and stretcher in a mortar of one part cement and two parts of sand. The concrete backing is of one part cement, three parts sand, and five parts gravel.

The face batter is ½ in. per foot; the south end 2 in. per foot. The north or up-stream end is provided with an ice breaker to 4 ft. above high water, coped with a starling 4 ft. high, above which the face is square and batters ½ in. per foot.

The bridge seats and ice breaker stones are dimensioned and cut at the quarry. One inch square cramps connect the ice breaker stones when laid.

The work was done under the direction of Mr. C. M. Ingersoll,* Chief Engineer of the Railroad Company, who has since been succeeded by Mr. Edward Gagel.

The steel work was designed by Mr. W. H. Moore, Bridge Engineer for the Railroad Company.

The work was executed under the general supervision of Mr. H. B. Seaman,* Assistant Engineer of Construction, to whom the writer was Assistant Engineer.

Messrs. Daly & Holbrook were the contractors for the masonry, and the American Bridge Company for the steel work.

The writer begs to thank Mr. Ernest W. Wiggin, Assistant Bridge Engineer of the Railroad Company, for his assistance as to data and information of the superstructure.

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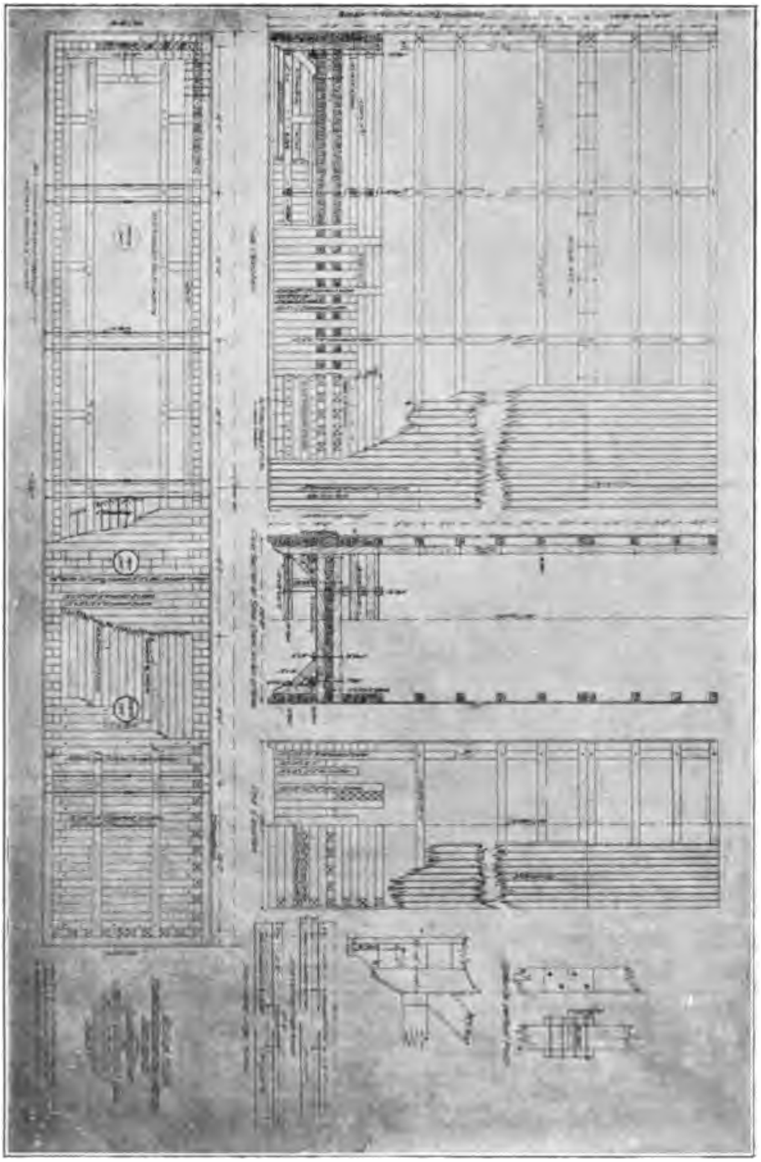
* Member, Municipal Engineers of the City of New York.

PLATE III.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MAZEAU ON HOUSATONIC RIVER
BRIDGE AT NAUGATUCK JUNCTION.



PLAN OF CAISSON AND COFFER-DAM.

DISCUSSION.

Mr. George W. Tillson, President of the Society.—The paper is now open for discussion. The subject is one about which many of you have had considerable experience and we would be glad to have a full discussion on the matter.

A Member.—How was the caisson kept in place?

The Author.—Until ready for sinking, it was held by lines and a row of piling.

Mr. Noah Cummings, Member of the Society.—As the width of the piers appears rather wide in the slides shown, I would like to ask the author what was the governing consideration in determining the width? Was it required in order to reduce the unit pressure on the stone down to safe limits, or were there other requirements that entered into the problem?

The Author.—The unit pressure was the governing factor.

Mr. E. M. Law, Jr., Member of the Society.—Was it possible to use open box caissons on any of the construction work?

The Author.—They were considered at one time. I would like to hear from some gentleman who has had experience in laying concrete under water.

Mr. John G. Theban, Member of the Society.—Did you have any trouble with laitance?

The Author.—We did have some.

Mr. Theban.—How much did you have for the deep piers?

The Author.—There was no maximum amount; it accumulated at the rate of about 1 in. for every foot in depth of vertical concrete, and when there were 10 or 12 in. it would be removed.

A Member.—Was the depositing of concrete kept on continuously day and night, or did you stop at the end of every working day and then start again?

The Author.—It was uninterrupted.

A Member.—At what depth was the concrete deposited?

The Author.—The depth varied from 20 to 48 ft.

A Member.—The bucket was lowered to the place where it was to be deposited right through the water and then opened?

The Author.—Yes.

Mr. Elmore F. Austen, Member of the Society.—You did not have a diver down there?

The Author.—Not continuously.

Mr. Austen.—I would like to ask, in that connection, if any observation was made after the concrete was deposited? Was an inspection made of the concrete to find out what condition it was in and how it set?

The Author.—During the depositing of the concrete there

were constant tests made by soundings and periodical inspections by divers.

Mr. Austen.—What was the result of that inspection?

The Author.—It showed that in every instance all concrete laid under water set and hardened the same as in air. Subsequently, when the cofferdam was pumped and the top of concrete footing was exposed preparatory to laying masonry, its condition left nothing to be desired.

Mr. Martin Gay, Member of the Society.—Notwithstanding the very general distrust of the sheet pile and of the open caisson methods for foundations, I know they can be used with entire safety in many cases and are much more economical than the plenum pneumatic process.

Perhaps the dissatisfaction and expense which have in so many cases attended the use of cofferdams have arisen from the expectation and endeavor of the designer to secure a water-tight enclosure in which to lay his masonry. But in these days of good and cheap Portland cement it is seldom worth while to spend much time or money in attempting to reach this ideal condition for work, when concrete deposited under water will, in most cases, give equally satisfactory results.

There are, of course, certain rules to be observed and considerable care to be exercised, and I fully agree with Mr. Mazeau that in concreting under water there should be no stoppage of work from beginning to end. It should go on continuously, particularly if the concrete is being placed in an enclosure through which there is no current of water to carry off the floating cement, otherwise there will be a deposit of laitance between layers of concrete.

We had an experience of this kind when building the Macomb's Dam Bridge. The center pier was built on an annular caisson which was founded on rock, and it was expected that the rock would be so watertight that the central well, inside of the caisson, could be pumped out and the concrete put in, in the dry. But after the caisson had been sealed and an attempt made to pump out the water, it was found to come in through seams in the rock with such a flow that it could not be controlled. It was therefore necessary to fill the well up to about low water mark with concrete deposited under water. In the course of this work there were a few delays, perhaps of a night each, and when the well had been sealed and the water pumped out, and the timbers which formed the inside wall of the caisson removed, we found several heavy deposits of laïtance at the outer edge of the mass of concrete, which from their position we could see were formed on those nights when work had been stopped. Fortunately, it was possible to get at them and remove the soft material.

Some time after this we built a center pier for the Harlem Ship Canal Bridge, of about the same character, where work was continued night and day without intermission, with very satisfactory results. Except on the top surface no laitance was found and the concrete, so far as we could discover, was a monolith of very dense and excellent character.

THE AUTHOR.—I believe that the experiment of having open slits in the cofferdam through which the laitance is squeezed out as the concreting progresses has proved successful.

MR. TILLSON.—I hope there is no one else here who is so modest as Mr. Gay, who had so much to say, but would not say it without being called upon.

Is there nothing further to be said, gentlemen? If not, the business of the evening is concluded.

MR. HORACE J. HOWE, Member of the Society (by letter).—There is some doubt in my mind whether this method of depositing concrete under water is the best method, under the circumstances described by the author.

There is nothing particularly new about depositing concrete by bucket, and I need not dwell on the matter of the uncertainties by day and night; but rather call attention to the method of somewhat more recent date, but common here and elsewhere at present, the method of enclosed chutes.

In 1896 and 1897 this was in vogue at the Charlestown Bridge over the Charles River—William Jackson, Chief Engineer—and a full description is contained in the 1897 Report of the Boston Transit Commission. From time to time I had occasion to observe the doings at the bridge, in an unofficial capacity, and recently wrote Mr. Jackson regarding the method, in the interests of the Municipal Engineers.

The following is his very courteous reply:

CITY OF BOSTON.
ENGINEERING DEPARTMENT,
50 CITY HALL.

MARCH 15TH, 1906.

Subject: Depositing concrete under water.
L. B. 28, pg. 290.
No. 11,317.

MR. HORACE J. HOWE,
25 Gold Street, Yonkers, N. Y.

DEAR SIR:—Yours of the 11th inst. is received, and in answer to your inquiry I have to say that the method used for depositing concrete under water at the Charlestown bridge is now in use in this

City. The first considerable work on which this method was used in this City was for the Piers of the Harvard bridge, built about 1888. The same process was used on the Dover Street bridge 4 Piers, built in 1894; on the Summer Street bridge 4 Piers and Abutments, built in 1899; on a sea-wall near the Summer Street bridge, built in 1900; on the 10 piers and 2 abutments of the Cambridge bridge in 1900-2, and the Northern Avenue bridge piers and abutment now under construction. The results in every case have been satisfactory.

You will find an article by S. E. Thompson, in the *Engineering News* of October 17, 1901, which gives a very good description of the method used on Cambridge bridge, also on page 19 of the specifications for Piers and Abutments, Northern Avenue Bridge, sent under separate cover, you will find method prescribed.

Yours truly,

William Jackson,
City Engineer.

FROM SPECIFICATIONS OF NORTHERN AVENUE BRIDGE.

Section 8.—Portland Cement Concrete in Foundations.

(*a*.) The spaces inclosed by the sheet pile and plank curbings are to be filled with Portland cement concrete to the grade shown on the plans, deposited to within 1 ft. of the top through a water-tight tube, in layers not exceeding 2 ft. in thickness, unless otherwise directed. This tube is to be fed from a hopper of sufficient capacity to enable the concrete to be deposited without interruption, and the hopper must at all times during the use of the tube contain enough concrete to fill the tube twice.

(*b*.) Care is to be taken to prevent the empyting of the tube of concrete, except at the discontinuance of its use, or when necessary to lift it over possible obstructions, or out of water. In case of the tube becoming full, or partially full, of water, it shall be lifted slightly and the water expelled by suddenly filling it with concrete.

(*c*.) Concrete laid under water is to be allowed to set for at least forty-eight hours, or for such time as may be determined by the Engineer, before other concrete is placed upon it.

(*d*.) Channels and sumps are to be provided for collecting water which may leak through the sheeting, and the top surfaces of concrete and stonework, at and above the grades specified for concrete deposited under water, are to be kept free from water while additional work is being laid upon them. Care is to be taken to prevent the washing of concrete during the admission of water covering the same.

(*e.*) The concrete above that to be placed under water to be carefully deposited in layers of such thickness as may be directed, and well rammed to a surface sufficiently level to form a proper bed for the stonework.

(*f.*) Four lengths of 12-inch cast-iron water pipe, with quarter turns, are to be built in the concrete foundation of the abutment, as shown.

(*g.*) The quarter turns are to be secured by set screws in addition to the usual lead joint.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 23.

PRESENTED MARCH 27TH, 1906.

THE MANHATTAN BRIDGE, ITS TERMINALS AND CONNECTIONS.

BY OTHNIEL F. NICHOLS,* C. E., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEORGE W. TILLSON AND THE AUTHOR.

THE MANHATTAN BRIDGE AND ITS APPROACHES.

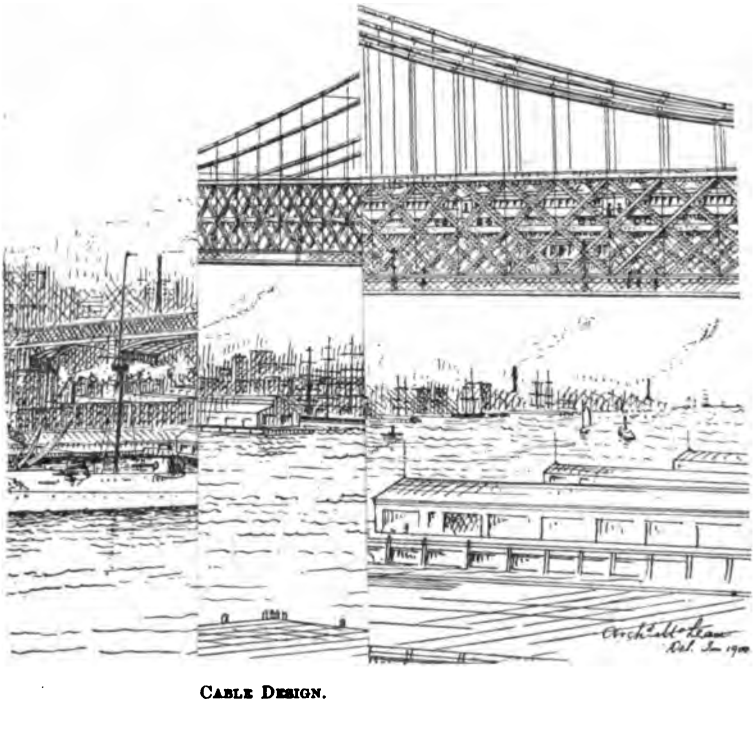
The population of the City of Brooklyn was about 600 000 when the Brooklyn Bridge was opened on May 24th, 1884. The number of passengers carried on the Bridge Railway in 1885 was 17 177 053 or about the number carried over the river before the bridge was opened on the four ferries from Atlantic Avenue to Catherine Street, inclusive. In 1890 the number of passengers carried over the river by these ferries and the bridge was as follows:

Four ferries	25 588 609
Bridge Railway	37 676 411
Total	63 265 020

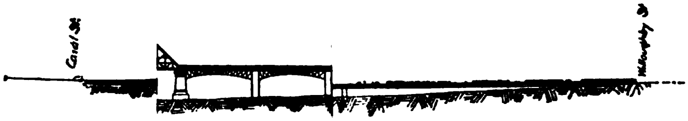
The growth of Brooklyn was very great between 1884 and 1890, due largely to the building of the elevated railway with the consequent upbuilding of the outlying districts. In 1894 the surface railways in Brooklyn were consolidated, they had been greatly extended and were operated by electricity, resulting in a still greater

* Consulting Engineer, Department of Bridges.

PLATE IV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.



CABLE DESIGN.



SIGN (PRELIMINARY).

"I therefore request that you will at once take all steps preliminary to action by the Municipal Assembly as to location, plans and construction of such a bridge.

"Without recommending any specific location, I suggest that the proposed bridge be placed between the New East River Bridge and the New York and Brooklyn Bridge.

"ROBERT A. VAN WYCK, *Mayor.*"

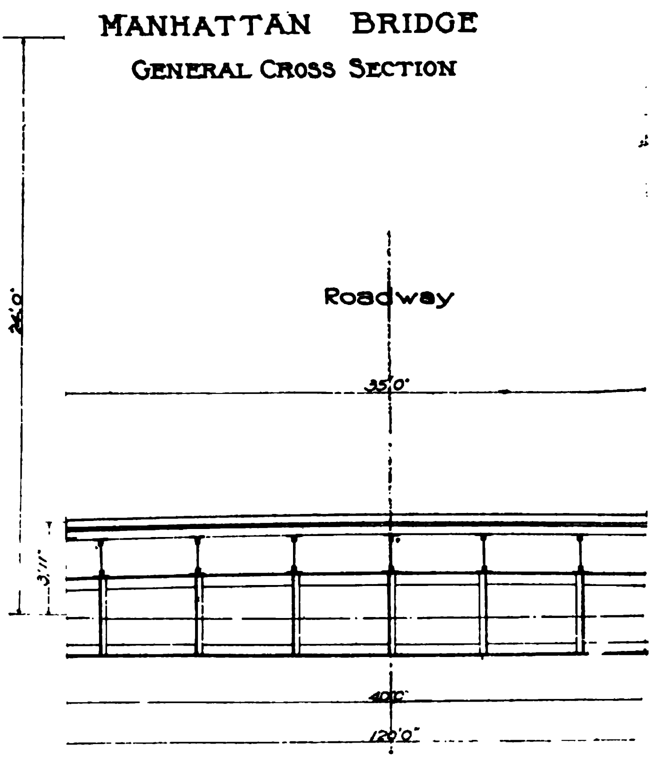
The Commissioner of Bridges was directed by unanimous vote of the Board of Public Improvements to prepare plans, etc., for a bridge over the East River to be located at some point south of the New East River Bridge. In response to this direction two plans were prepared, one for a cantilever and one for a suspension bridge located approximately on a line corresponding with the line of Flatbush Avenue extended to the corner of the Bowery and Canal Street, in the Borough of Manhattan. The plan for a suspension bridge was definitely selected and submitted to the Board of Public Improvements on November 28th, 1899, and was duly approved by that board the following day. (See Plate IV.)

An ordinance adopted by the Municipal Assembly on December 30th, 1899, and approved by the Mayor on January 8th, 1900, provided that:

"The building of a permanent bridge over the East River between the Borough of Manhattan and the Borough of Brooklyn, in the City of New York, from at or near the foot of Pike Slip in said Borough of Manhattan, to, at or near the foot of Washington Street in said Borough of Brooklyn, and the approaches thereto, in accordance with plans prepared under direction of the Commissioner of Bridges and approved by the Board of Public Improvements and filed in the office of the Commissioner of Bridges on the 29th day of November, 1899, is authorized and approved, etc., etc."

An appropriation of $50 000 had been authorized for preliminary work in January, 1899, and an additional appropriation of $1 000-000 was authorized in January, 1900. All of the projects for this "Bridge No. 3," including the original suggestion by President Howell of a bridge parallel to the old bridge, contemplated the extension of the southerly approach towards the junction of Flatbush Avenue and Fulton Street and substantially on a line with Flatbush Avenue.

PLATE V.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.



The extension of Flatbush Avenue to the old bridge had been suggested many years before and notably in 1883, just before the opening of the old bridge; persistent opposition to the extension was, however, then very active and was apparently almost as active in 1898. The low ground near the crossing of Myrtle Avenue would necessitate objectionable street grades in both directions and this objection was made one of the main features in the opposition to the extension.

The plans for the new bridge now approved by the municipal authorities called for a suspension bridge with 4 parallel main cables supplemented by 4 stiffening trusses, so placed as to provide space for 4 railway tracks on the lower or roadway floor and for 4 railway tracks over these on the second floor, with a carriageway about 35 ft. in width on the lower floor between the railway tracks and 2 footwalks on the same floor outside of these tracks. This cross-section has been retained on the final design. (See Plate V.)

The cables were to be secured to masonry anchorages at the ends and supported on steel towers located within the pier head lines and 345 ft. in total height above mean high water. The clear height of the bridge was made 135 ft. above mean high water for 400 ft. at the middle of the river span at most unfavorable conditions of temperature and loading.

The river span was made 1 465 ft. from center to center of towers and the land spans 850 ft. each from the center of the towers to the face of the anchorages. The Manhattan approach was made 1 940 ft. in length to the Bowery, and the Borough approach 4 230 ft. to Willoughby Street, the total length of the bridge being 9 335 ft.

The long Brooklyn approach was carried on a street viaduct as far as Willoughby Street and the approach was there deflected southerly to Fulton Street and thus avoided a direct extension of Flatbush Avenue. This long viaduct as a part of the bridge and the deflection to Fulton Street apparently disarmed the opponents to the construction of the bridge as an approximate extension of Flatbush Avenue.

The steel viaduct over the low ground was necessary if the bridge structure was to extend to Willoughby Street, but it involved serious difficulties, notably in crossing the elevated railroad

at Myrtle Avenue, and in the roadway connections with transverse streets.

The development of subway construction rendered the future use of the elevated railways on the bridge uncertain and the Board of Estimate and Apportionment subsequently, as had been anticipated, terminated the bridge approach at Nassau Street and authorized the extension of Flatbush Avenue in a straight line to the bridge at Nassau Street, placing the construction of this extension in the hands of the Borough President as a feature of highway development.

The location and elevation of the bridge over the river was approved by the War Department on January 29th, 1900. Plans were prepared for the Brooklyn tower foundation during the year 1900, and bids were received for doing this work on March 11th, 1901. These bids varied from $600 000 to $951 725.

A decision of the Court of Appeals then just rendered made it questionable whether a contract requiring compliance with the labor laws of 1897 and 1899 would be valid or free from attack, and the bids received were all thrown out and new bids were opened on April 22d, 1901, on a contract in which reference to the labor laws had been modified.

The bids for the Brooklyn tower foundation are shown on following page.

A contract was awarded on May 1st, 1901, to John C. Rodgers, the lowest bidder. The contractor made preparations to begin work at once; the caisson was launched on February 11th and towed into position ready for sinking on March 27th, 1902.

Bids were opened for the construction of the Manhattan tower foundation on December 2d, 1902, resulting in bids shown in table, page 22.

The contract was awarded to John C. Rodgers, the lowest bidder; the caisson was launched during the week ending May 20th and was towed into position for sinking on July 28th, 1903.

Studies for the anchorages, towers and stiffening truss were made during 1901, and these were so far advanced that it was expected that contracts for the anchorages and at least for the steel towers could be made during the year 1902. The mayoralty election of 1901 resulted, however, in a change in the administration of the Bridge Department and the new Commissioner determined

MANHATTAN BRIDGE (No. 3).

Bids, Brooklyn Tower Foundation, April 22, 1901.

(Labor Clause cut out.)

Item.	Quantity, cubic yards.	J. C. Rodgers.		McMullen, McBean.		Williams, Gerstle.		Liebmann, Gahagan.		United Engineering & Contracting Co.		Norton & Kirk.		McMullen, McBean.	
		Unit price.	Amount	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Alternate.	
a......	....	....	$470 000	....	$472 400	....	$517 792	....	$519 575	....	$557 000	....	$610 800	....	$460 000
a_1......	600	$1	600	$10	6 000	$7.75	4 650	$10	6 000	$18	10 800	$15	9 000	$10	6 000
b......	500	1	500	10	5 000	18.00	9 000	25	12 500	20	10 000	17	8 500	10	5 000
b_1......	100	1	100	10	1 000	8.25	825	10	1 000	40	4 000	15	1 500	10	1 000
c......	250	1	250	10	2 500	21.00	5 250	25	6 250	20	5 000	15	3 750	10	2 500
c_1......	50	1	50	10	500	9.00	450	10	500	45	2 250	15	750	10	500
d......	125	1	125	10	1 250	24.00	3 000	25	3 125	25	3 125	15	1 875	10	1 250
d_1......	25	1	25	10	250	12.00	300	15	375	45	1 125	15	375	10	250
e......	60	1	60	10	600	28.00	1 680	25	1 500	35	2 100	16	960	10	600
e_1......	12	1	12	10	120	20.00	240	25	300	50	600	20	240	10	120
f......	30	1	30	10	300	38.00	1 140	25	750	30	900	20	600	10	300
f_1......	5	1	5	10	50	25.00	125	25	125	50	250	30	150	10	50
Totals........			$471 757		$489 970		$544 452		$552 000		$597 150		$638 500		$477 570

MANHATTAN BRIDGE (No. 3).

BIDS.—MANHATTAN TOWER FOUNDATION.—DECEMBER 11TH, 1902.

Item.	Quantity Cu. Yards.	J. C. RODGERS.		JOHN G. TAIT.		D. D. MCBEAN.		DEGNON-MCLEAN.	
		Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.	Unit price.	Amount.
a	Completed Work. to — 79.15 ft.	....	$450 000.00	....	$480 000.00	....	$500 000.00	....	$612 500.00
b	— 79.15 ft. to — 88 ft. 1 608	$10.00	16 080.00	$10.00	16 080.00	$7.50	12 015.00	$43.00	68 886.00
c	— 88 ft. to — 87 ft. 1 664	10.00	16 640.00	10.00	16 640.00	7.50	12 480.00	36.00	59 904.00
d	— 87 ft. to — 91 ft. 1 664	0.01	16.64	0.01	16.64	7.50	12 480.00	26.90	44 761.60
e	— 91 ft. to — 95 ft. 1 664	0.01	16.64	0.01	16.64	7.50	12 480.00	25.60	42 598.40
f	— 95 ft. to — 99 ft. 1 664	0.01	16.64	0.01	16.64	7.50	12 480.00	24.60	40 934.40
g	— 99 ft. to — 103 ft. 1 664	0.01	16.64	0.01	16.64	7.50	12 480.00	19.50	32 448.00
Totals..............			$482 726.56		$512 726.56		$574 415.00		$902 032.40

in March, 1902, to change the type of the structure and to design a stiffened suspension bridge having a pin-connected eye-bar cable supported on slender steel towers resting on a large pin at the top of the masonry piers about which the towers were free to move under variations of temperature and of load. Each cable was composed of eye-bars of nickel steel about 18 in. in width and 2 in. in thickness; the pins were about 18 in. in diameter and the bars about 45 ft. in length. The pins were about 6 ft. long to hold the 80 or more bars reaching them from both directions. The land spans were materially shortened and the anchorages were elaborately designed and intended to provide assembly halls, each capable of accommodating upwards of 2 000 people. (See Plate VI.)

The work on the new design was advanced with great vigor during the years 1902-03; they were approved by the Art Commission early in 1903 and by a board of expert engineers appointed by the Mayor in reports dated March 9th and June 29th, 1903. The original plans, having been adopted by the municipal authorities prior to 1901, did not under the existent charter require the approval of the Art Commission, but the charter amendments taking effect early in 1902 made this approval of the new plans obligatory. The Board of Estimate and Apportionment authorized the issue of $6 500 000 of bonds for the construction of the anchorages and superstructure in May, 1903, and this authorization, although twice presented to the Board of Aldermen, was rejected by them on both occasions.

Land was condemned on new sites, shortening the land spans and making them supposedly too short for an ordinary suspension bridge, and contracts were made for granite pedestals to be added to the masonry piers, which would adapt them to the new design, but render them unfit for the steel towers of the original design.

The merits of the two designs were discussed at great length by able engineers in the technical journals of 1903 and in Volume LV of the *Transactions* of the American Society of Civil Engineers. The proposed structure would have been entirely experimental; no structure of the kind had ever been built; it involved the construction of eye-bar chains over the river by untried, expensive and new methods of construction, and it required the use of eye-bars of dimensions and character such as have, even now, never been made,

and it is still true as it was in 1903 that there is no machinery in the world capable of making such bars. It was claimed that the structure could be built in less time and at less cost than the wire cable suspension bridge; this, however, was a mere assertion, incapable of proof, while the converse proposition was far more likely to be correct.

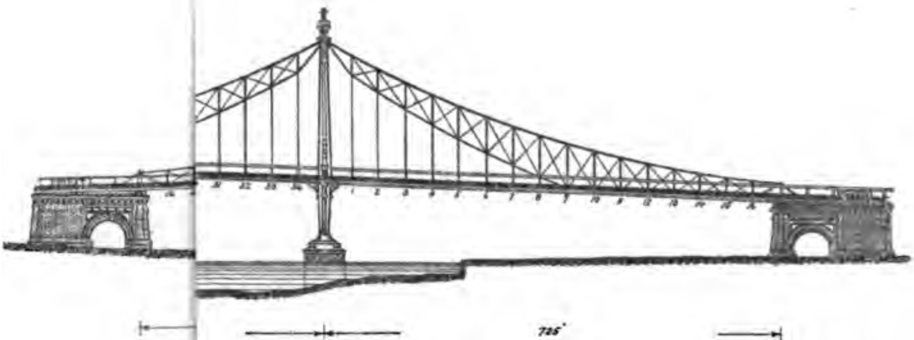
The anchorages could not cost less than $2 500 000, the steel work would weigh at least 50 000 tons or 8 000 tons more than the wire cable design, and could not be built for less than $7 000 000, so that the appropriation asked for was totally inadequate for the purpose intended. The untried experiment of making and erecting the eye-bar cables would have consumed many years and the construction of this bridge would have occupied several years more time than that reasonably allowable for an ordinary suspension bridge. On the other hand, there is little doubt that if the contracts for the structure had been awarded on the original wire cable plans, as was intended in 1902, the bridge could easily have been completed ready for use on or before the first day of July, 1907.

The failure to secure money to construct the eye-bar bridge stopped all work on the structure during the balance of the year 1903. The mayoralty election of that year virtually settled the question as to type of structure and determined that the bridge should be of the ordinary wire cable type. Shortly after the election of 1903 and when it was definitely known that there would be a change in the city administration, the original plans for the bridge were submitted to the Art Commission for rejection, but that board declined to consider these plans in this way.

It was believed that the original design for the bridge, however complete and satisfactory from a purely engineering standpoint, might be much improved from the standpoint of architectural æsthetics, and the work of preparing new designs with this idea in view and to adapt the structure to the changes made in the location of the anchorages and in the construction of the tower foundations was begun about February 1st, 1904, and the eye-bar design was formally rejected, on June 15th of that year.

The new plans (see Plates VII and VIII) were submitted to the Art Commission in June and were finally approved on September 20th, 1904; throughout this period the attacks on the Bridge Depart-

PLATE VI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.



ment by a few of the newspapers and by certain civic associations were unceasing and bitter, and every effort was made to secure the rejection of the plans. The Art Commission considered the subject carefully and conducted its several hearings with dignity and ability. The following letter is quoted as condensing the reason for the rejection of the eye-bar design and the return to the wire cable design:

JULY 11TH, 1904.

TO THE HONORABLE THE ART COMMISSION OF THE CITY OF NEW YORK,
City Hall, New York City.

Gentlemen:—I am in receipt of a letter from the Assistant Secretary of the Commission, dated July 7th, 1904, and reading as follows:

> "I am directed by the Committee having in charge the "designs of the Manhattan Bridge to request you to furnish and "file at the meeting of the Commission next Tuesday afternoon, "at four o'clock, such definite statement as you may see fit of "the reasons for the rejection of the plans formerly approved "by the Art Commission, and for the substitution of new ones "therefor; and also of the extent to which the plans now be-"fore the Art Commission have so far been adopted as, subject "to the approval of the Art Commission, presumably to be car-"ried into effect.
>
> "May I add that you are a member of the Commission for "the consideration of these designs, and they will probably be "considered at the meeting of the Commission next Tuesday "afternoon, July 12th, at 4 P. M., in this office."

The Manhattan Bridge was authorized by the Board of Public Improvements in 1899 and its construction was approved by the Municipal Assembly and the Mayor in January, 1900, "in accordance with plans prepared under the direction of the Commissioner of Bridges and filed in the office of the Bridge Department on November 29th, 1899." These plans provided for the construction of a wire cable suspension bridge similar to the bridge covered by the plans now before the Art Commission, and were never, so far as I can ascertain, officially rejected pursuant to law, although about November 16, 1903, they were submitted by the Commissioner of Bridges to the Art Commission, and thereafter were withdrawn from its consideration without any action having been taken thereon.

I am, I believe, in duty bound to adhere to the terms of the

original authorization of this structure and to the type of a wire cable suspension bridge originally adopted, unless the interests of the city should seem to me to require some other type of construction, in which case the approval of the Board of Estimate, the Board of Aldermen and the Mayor, and of the Art Commission, would have to be obtained to sanction the change.

In response to a request from the Bridge Commissioner on this subject, the Corporation Counsel rendered an opinion on January 30, 1902, in part as follows:

> "I do not think these plans can be changed without the "authorization of the Board of Aldermen. I think it would be "safer and better if you desire to modify the plans in any ma-"terial respect to get the authorization of both the Board of "Estimate and Apportionment and of the Board of Aldermen."

On assuming office I directed my engineers to revise the original plans of the Manhattan Bridge, with a view of securing the approval of the Art Commission, as required by the amended charter, and retained architects, who had not been in any way connected with previous plans for the bridge, to give architectural expression to the design in order to make it a pleasing as well as a useful structure.

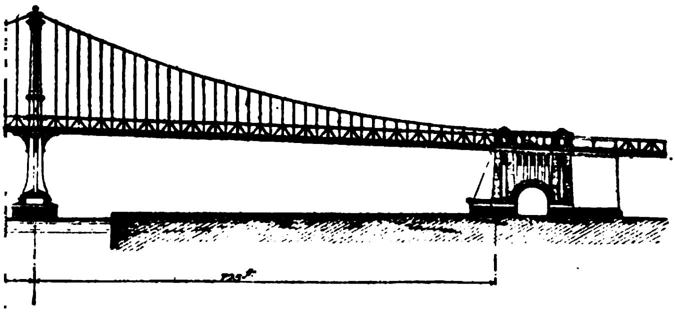
General plans and detailed specifications had been prepared during 1902-3 for a structure radically different in type from those of the original design and involving the use of eye-bar chains instead of wire cables. These plans had been carefully prepared from the æsthetic standpoint, and received the approval of the Art Commission on March 10, 1903.

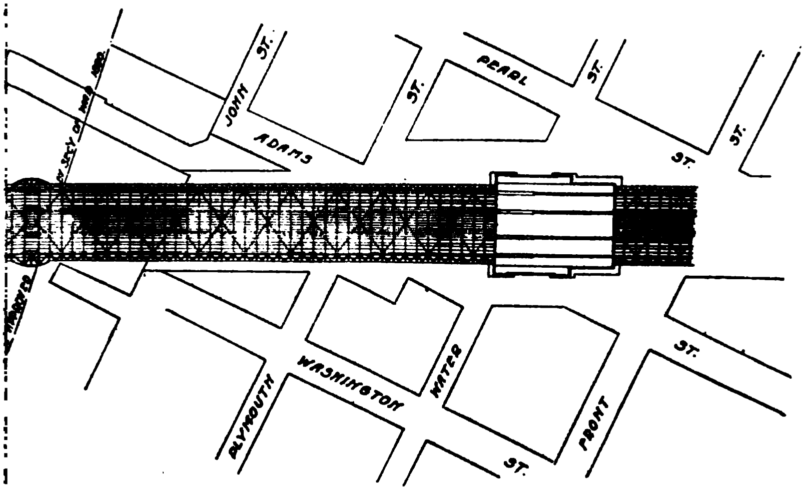
In January, 1904, four years had elapsed since the authorization of this structure; during the corresponding period on the Williamsburgh Bridge the anchorages had been made ready for the cables, the steel towers and end spans had been built and all the major contracts, excepting that for the suspended span, had been let; and this, notwithstanding the fact that serious delays and hindrances had occurred, arising chiefly from want of funds and labor troubles. While the Williamsburgh Bridge was seriously delayed in construction, it was actually built within the time prescribed in its original charter, and such delays as did occur were in no wise attributable to the design selected and do not detract from its value as a standard from which to estimate the probable time for the completion of similar work.

The Manhattan Bridge is to-day more important and more necessary to Brooklyn than either of the earlier bridges over the East River were when built. I cannot hope to have it completed

PLATE VII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.

BROOKLYN





ER DECK.

during my term of office, but I can, at least, take such action as will expedite the work upon it and assure its early completion; the question, then, of greatest importance presented to me was this, which type of bridge can be most quickly completed? It is now known, with a great degree of certainty, how long it will require to build a wire cable suspension bridge, for the city has already built two such bridges, and is in a position to profit by the experience gained in their construction. On the other hand, nothing definite is known as to how long it will require to build a large eye-bar chain bridge. No structure of the eye-bar type, approaching this in magnitude, has ever been built; the material of which the bars must be made has never been used in bridge construction; and the bars themselves are of dimensions far beyond any which have ever been made. A large portion of the delay in building the Brooklyn Bridge was due to the want of knowledge at that time of the manufacture and use of steel, and a portion of the delay in the completion of the cables of the Williamsburgh Bridge was due to inexperience in working the special steel required into wire of the dimension and length prescribed.

The size of the bars and pins required for an eye-bar is so large and the difficulties of erection of the rocking towers and the huge and unwieldy bars is so great that special and unusual machinery, apparatus and methods must be invented and used in the manufacture of the material, the shaping of the members and in their erection. The uncertainty as to how easily or in what time these things can be done makes it absolutely impossible to predict when such a bridge could be completed, but makes it certain that the wire cable bridge, of which we have positive knowledge, can be finished in very much less time.

Your attention has been called to the fact that the wire cable bridge may be less rigid than the eye-bar chain bridge; the Board of U. S. Army Engineers, who reported on the plans for proposed bridges over the Hudson River, remarked that:

> "The great distinction between the stable equilibrium of "a suspension bridge which cannot break down from failure "of any stiffening member and the unstable equilibrium of a "truss arch or cantilever bridge in which the failure of a single "member may involve the collapse of the entire bridge ought "to receive full recognition in the adoption of unit stresses "and safety factors."

And again:

> "Rigidity is in this case of much less importance than it is "in most other kinds of bridges; indeed, it may be shown that

"a certain amount of flexibility is a positive advantage in sus-"pension bridges—the Board does not doubt that, within nar-"row limits, a certain degree of flexibility is an advantage to "the bridge."

And the late George S. Morison wrote, in referring to the changes in shape incident to changes in load in a suspension bridge:

"These changes of shape play an important part in suspen-"sion bridges, and so long as they are kept within limits which "do not disturb convenience of operation, they are a source of "strength instead of weakness."

It is due to this fact that suspension bridges have successfully endured the most excessive loading, as in the case of the Niagara Bridge and the Brooklyn Bridge.

I have directed that the new plans shall provide for precisely the same loading and capacity as prescribed for the eye-bar chain design, and these can be more easily and economically provided for with wire than with chain cables. It is well known that steel reaches its greatest strength when drawn into wire; the wire drawing develops the strength and tests the material as well. Of course, no single eye-bar of the 8 or 10 thousand which would be required for a chain bridge could be tested as to its strength and afterwards used; actual tests of full-sized specimens would, therefore, all be vicarious and leave great uncertainty as to the actual condition of the steel in any bar used in the bridge. Pieces of wire from both ends of every one of the 30 000 wires used in the Williamsburgh Bridge were tested by breaking and the actual strength of every one of these wires is therefore definitely known.

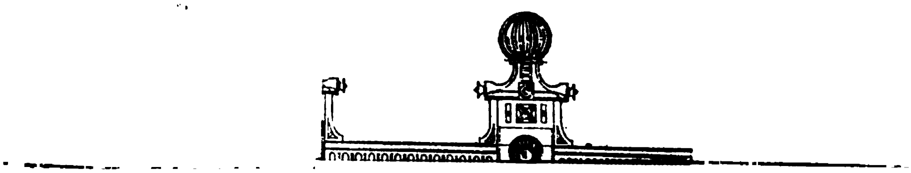
The relation of the material for the two types of bridges is in other respects especially favorable to the wire cables. The Board of Army Engineers remarked:

"The connections for a series of links (eye-bars) add 20 to "25 per cent. to the dead weight of the chain, while in the form "of wire has a minimum strength more than double its maxi-"mum strength in the form of bars suitable for the construc-"tion of a suspension chain."

As a matter of fact, the material used for the eye-bar chain would weigh more than twice as much, would cost at least 50 per cent. more, and would then be only about half as strong as the wire for the cables.

It has been said that the Manhattan Bridge will be the most expensive of all the bridges over the East River. The increased

PLATE VIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.



loading beyond that prescribed for the Williamsburgh Bridge and the addition of two elevated railway tracks will increase the cost materially over the estimates made for the original plans. It is now known that the estimated cost of about 6½ million dollars for building the portion of the eye-bar chain bridge now under consideration must necessarily be increased to nearly ten million dollars. The wire cable bridge for the same construction will contain ten thousand tons less steel, and it now seems probable that the entire cost of the portion of the structure covered by the new plans will not exceed 8½ million dollars.

For the reasons above given, and others which time does not permit me to detail, I have had no hesitancy in rejecting the eye-bar chain type of construction for the Manhattan Bridge and in substituting therefor a type of bridge which the city has built in two instances for even longer spans. It seems to me the part of prudence and in the line of safety, expedition and public interest to avoid indulgence in a colossal experiment, and to confine our efforts to the safe, sane ground of what may be termed for the City of New York every-day experience. No living soul can predict with any degree of certainty when an eye-bar chain bridge could be completed, but we can tell, accidents aside, within a fraction of a year when the wire cable bridge can be opened to the public, and very accurately what it will cost.

I am well aware that a commission of celebrated engineers passed favorably upon the design for the eye-bar chain bridge, and I am far from denying that a structure of that type can be built at this site. This commission made no technical comparison between the two types of bridges and their incidental remark that a chain bridge could be built more rapidly and cheaply than a cable bridge must be regarded as a mere expression of personal preference, because there is absolutely no data in existence from which to determine with the remotest degree of accuracy what the cost of the chain bridge will be in either time or money.

The element of certainty against uncertainty, both as to cost, time and safety, seems to me conclusive; and now that the architects have given adequate expression, perhaps never before accomplished, to the airy lightness and elastic stability of the suspension bridge in the plans submitted for your approval, I feel sure that the city has it within reach to secure a strong, an efficient and a beautiful bridge at a reasonable cost and within a reasonable time.

The Greater New York Charter requires from your honorable body approval of the architectural or æsthetic features of structures of this kind. The same instrument imposes upon me the responsibility for the design and construction of such works, aided, as I

am, by engineers of experience and skill. The studies of this problem which have been made by these engineers, and my own knowledge of the facts and conditions of the case, convince me that an eye-bar chain bridge should not be built at this site and that a wire cable bridge is the only suitable one, and the only one for which I can undertake to be responsible.

The plans submitted to you cover the æsthetic features of the proposed bridge, the detail working drawings for the structure are now well under way, $10 000 000 are now available for the work, and I expect to award the contracts for the anchorages within sixty days and those for the steel structure within a few months after the general plans now before you have been made satisfactory to the Commission.

Many points must remain untouched in a communication of this character. Should it seem desirable to you to go into the subject more in detail, or should any other reasons seem to you to require it, I shall be glad to have the engineers of the Department of Bridges and the architects appear before the Commission at any time.

Respectfully yours,
GEO. E. BEST,
Commissioner of Bridges.

Detailed plans for the structure were commenced as soon as the general plans had been approved by the Art Commission, and the following bids were received for both anchorages in February, 1905:

Contracts were awarded to the lowest bidders for both anchorages.

The Brooklyn tower foundation had been secured on the rock at a depth of 92½ ft. below high water early in 1903.

The Manhattan tower foundation reached elevation —92½ in December, 1904; at this depth the foundation rested on a coarse sand or coarse sand with fine gravel very firm in character. Various experiments had been unsuccessfully made, late in 1903, to force grout into this material in order to compact it. These experiments delayed the completion of the foundations several weeks, at a time when the pressure was so great as to cause serious danger to the men, several of whom had died during this interval. A careful examination of the foundation and study of the conditions imposed resulted in a decision to fill the caisson and complete the foundation on this material and at an elevation some 20 ft. above the rock.

MANHATTAN BRIDGE (No. 3).

Bids for Brooklyn Anchorage, December 22, 1904.		
Contractor.	Lump Sum.	
	Brooklyn Anchorage.	Both Anchorages.
Engineer's Estimate	$1 373 000	....
Kosmos Engineering Co	1 212 554	....
Williams Engineering & Contracting Co	1 237 000	$1 237 000
Naughton & Co	1 282 900	1 282 900
J. J. Hopper	1 337 848	1 337 848
Ryan & Parker Co	1 398 000	....
R. H. Hood Co	1 511 884	1 611 884

Bids for Manhattan Anchorage, December 22, 1904.		
Contractor.	Lump Sum.	
	Manhattan Anchorage.	Both Anchorages.
Engineer's Estimate	$1 407 000	....
Williams Engineering & Contracting Co	1 197 000	$1 197 000
Naughton & Co	1 296 150	1 296 150
J. J. Hopper	1 396 140	1 396 140
J. C. Rodgers	1 409 000	....
R. H. Hood Co	1 587 460	1 687 460

Plans and specifications for the towers, cables and steel superstructure were completed early in the summer of 1905 and the bids were received for this portion of the bridge on August 10th of that year, as shown in Plate IX.

An official of the company making the second lowest bid brought a "taxpayer's suit" to restrain the award of the contract to the lowest bidder; this suit was decided against the city and the decision was sustained by the Appellate Division of the Supreme Court, published in the *Law Journal* of January 18th, 1906, one of the judges dissenting. The decision of the Appellate Division is long and almost necessarily involved; the Court held that the contract and specifications were illegal and that a valid contract could not be made on the terms proposed. The main clauses in the contract which were declared illegal permitted extra work under certain conditions by supplementary agreement. This feature existed in most of the large contracts of the Department of Bridges and in many other city contracts and was neither new nor untried, but had never before been contested in the courts.

Nickel steel had never been used to any great extent in bridge construction, and there is even now much uncertainty as to whether it can be used to advantage in a large structure of this kind. There would, however, be a material advantage in its use in the stiffening trusses of this bridge to reduce the thickness of the members and to shorten the length of the rivets to be driven in the field. A rather high grade of acid carbon steel had been specified for the other portions of the bridge, the same in fact as that used for the cables, which could not be made from other material. This steel was known to be somewhat expensive; it was believed that the cost of using it in the trusses would be about the same as that for the nickel steel, and the option was given the engineer of selecting which of these two materials should be used at the same price per pound.

The Court could not be charged with engineering knowledge and was misled by the principal affiant for the plaintiff, ignoring the specific determination of the relative proportions of the two materials if used, which was given in a table which only engineers could fully understand. The testimony for the plaintiff was misleading and apparently not adequately offset in the

PLATE IX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.

'RUCTURE.

	Milliken Bros.			The King Bridge Company.		
l.	Quantity.	Unit price.	Total.	Quantity.	Unit price.	Total.
A						
		Cents.			Cents.	
6.00	1 355 800	4.94	$66 976.52	1 325 000	5.9	$78 175.00
4.00	3 945 200	5.2	205 150.40	3 724 000	5.2	193 648.00
0.00	317 600	13.85	43 987.60	308 000	7.0	21 560.00
0.00	1 500	8.81	132.15	1 500	8.0	120.00
0.00	400	39.5	158.00	500	40.0	200.00
0.00	85 600	5.94	5 084.64	18 000	6.5	1 170.00
T0.00	....	....	....	....	....	....
2.00	23 889 700	8.06	1 925 509.82	21 436 000	12.5	2 679 500.00
4.00	3 406 900	8.08	275 277.52	3 670 000	8.0	293 600.00
6.00	168 900	6.75	11 400.75	250 000	12.0	30 000.00
0.00	930	$7.71	7 170.30	930	$12.00	11 160.00
0.00	21 000	10.12	2 125.20	21 000	10.0	2 100.00
C0.00	....	....	....	....	....	....
0.00	13 015 576	15.02	1 954 989.51	13 015 600	15.5	2 017 418.00
2.00	1 530 804	17.33	265 201.68	1 530 800	18.0	275 454.00
0.00	2 120 192	14.6	309 548.03	2.216 000	13.0	288 080.00
0.00	88 100	12.26	10 801.06	72 200	19.0	13 718.00
0.00	96 000	18.38	17 644.80	96 000	18.0	17 280.00
0.00	15 680	62.48	9 796.86	15 700	60.0	9 420.00
0.00	24 722	17.3	4 276.90	24 700	17.0	4 199.00
0.00	6 500	116.0	7 540.00	6 500	110.0	7 150.00
St						
0.00	19 659 800	8.0065447	1 574 070.68	16 250 000	10.0	1 625 000.00
3.00	18 820 500	6.764	1 273 018.62	20 300 000	8.2	1 664 600.00
0.00	42 900	9.48	4 066.92	133 000	10.0	13 300.00
1.00	33 000	8.5	2 805.00	94 000	8.0	7 520.00
0.00	32 800	15.36	5 088.08	47 000	9.0	4 230.00
0.00	6 400	35.14	2 248.96	9 000	40.0	3 600.00
In.00	44 343	$1.20	53 211.60	42 282	$1.20	50 738.00
3.00	....		$7 983 970.00	....		$9 312 940.00

answering affidavits. Neither the relative values of the two materials as definitely stated in the specifications nor their relative cost as given in the affidavits were understood by the Court, and this misunderstanding is perfectly evident in the decision which pronounced the alternative use of carbon or nickel steel to be inequitable.

The courts refused to certify the case for appeal and there this litigation ended. The specifications for the steel superstructure of the bridge were at once revised. The clauses permitting the making of supplementary agreements and providing extra pay therefor were excluded, as was the clause covering the optional use of carbon or nickel steel for portions of the stiffening trusses. When these omissions were made the criticisms contained in the decision of the Court were fully met so far as these specifications and this decision were concerned. The plans had never anticipated the use of anything but nickel steel in the important members of the trusses and were all based on the use of this material, so that no change was made in them other than to add several drawings amplifying the information already given.

A few changes were made in the specifications other than those required to meet the judicial criticism, and these were generally made in order to reduce the cost of the work. A cheaper basic steel was permitted instead of acid steel and the time of completion was extended to correspond with the time lost in the litigation.

Before the bids on the new plans and specifications were opened, however, another delay occurred. The advocates of the eye-bar bridge were to make their final effort. The Comptroller had had doubts instilled into his mind as to the merits of the two designs and gave notice of a hearing at his office at which the advocates of the eye-bar design would have opportunity to present their views. No one, however, appeared at this meeting to advocate the claims of the eye-bar bridge; the hearing was adjourned a few days, and again no one appeared to advocate the eye-bar bridge and the Comptroller pronounced himself ready to proceed with the accepted design.

A Brooklyn property owner was, however, found, who secured a temporary stay enjoining the award of a contract until the eye-bar plans should be advertised with the wire cable plans. The chief

supporting affidavit on the side of the plaintiff was furnished by one of the experts who had served on the Mayor's Commission in 1903, and three of the other members of this board made answering affidavits. The plaintiff's case was extremely weak and laid itself specially open to attack by errors of statement in the moving papers.

The case was heard before Judge Bischoff, who rendered a decision from which the following extract is made:

"Upon the proof before me it is apparent that the question whether the 'eye-bar' or the 'wire cable' design for a bridge of the character of this structure is the better, presented a problem wholly for the Commissioner to decide in his discretion, aided by the professional advice open to him. The matter was within his lawful choice, and the affidavits do not indicate in any way that this choice was influenced by sinister motives. Nor can it be said that the rejection of the 'eye-bar' system, without taking bids upon it, was improvident, since it was with the wisdom of this form of construction, not with the single factor of comparative cost, that the Commissioner's decision was concerned. Possibly, as an engineering problem, the matter might have been received differently if alternative bids were taken and a substantial difference in cost were found in favor of the 'eye-bar' system for consideration against its disadvantages, but there is no apparent ground for the contention that this system must needs be materially the cheaper, and the Court cannot say that the failure to take bids, as an experiment, before rejecting the 'eye-bar' design was an omission which affected the Commissioner's lawful exercise of judgment. I find no more than a disagreement of opinion and a conflict of judgment arising between the plaintiff and the defendant as to the latter's official acts, a dispute in which the arbitration of the Court may not be involved (Talcott *vs.* City of Buffalo, 125 N. Y., 280). It is also asserted that the defendant's failure to supply bidders, with the information to be derived from a 'strain sheet' affected the price bid for the work, but this information was, as appears, wholly unnecessary to bidders, in view of the actual specifications furnished, and was reasonably omitted, in the Commissioner's discretion, as having no actual bearing upon the matter of the bid. The public importance of this work and the necessity for its completion, without undue delay, required that such an application for an injunction be closely scrutinized and the injunction withheld unless a case of apparent merit calling for a relief within the power of the Court to grant is shown. It may be that the moving affidavits taken alone would suggest ground for an injunction if the facts were unex-

MA

	Milliken Bros.			The American Bridge Co.		
	antity.	Unit price.	Total.	Quantity.	Unit price.	Total.
Anchorage						
F. O. B. Bri					Cents.	
Riveted v	355 800	$0.04	$54 232.00	1 312 000	4.75	$62 320.00
Eye-bars	945 200	0.042	165 698.40	3 728 000	5.0	186 400.00
Pins	317 600	0.08	25 408.00	342 000	7.50	25 650.00
Steel cast	1 500	0.065	97.50	1 500	20.0	300.00
Bronze...	400	0.3636	145.44	500	$1.50	750.00
Iron cast	85 600	0.0381	3 261.36	22 000	10.0	2 200.00
Towers.						
Riveted						
tural m	889 700	0.0785	1 755 893.95	22 376 000	8.25	1 846 020.00
Steel cast	406 900	0.0746	254 154.74	3 429 000	10.25	351 473.00
Iron cast	168 900	0.0665	11 231.85	616 000	14.0	86 240.00
Concrete,	930	10 80	10 044.00	950	$15.00	14 250.00
Cables, Susp	*30 200	0.0564	1 703.28	*18 000	8.25	1 485.00
Cables...	015 576	0.142	1 848 311.79	12 842 000	14.0	1 797 880.00
Suspende	500 104	0.164	246 017.05	1 177 000	15.0	176 550.00
Steel ca bands, saddles	120 192	0.126	267 144.19	1 863 000	15.5	288 765.00
Iron cast	88 100	0.094	8 281.40	63 000	12.75	8 033.00
Pins, bolt	96 000	0.173	16 608.00	77 000	10.0	7 700.00
Bronze ..	15 680	0.60	9 408.00	12 000	40.0	4 800.00
Zinc for	24 723	0.164	4 054.40	26 000	30.0	7 800.00
Lead fille	6 500	1.00	6 500.00	7 500	10.0	750.00
Suspended S						
Nickel-st	659 800	0.079	1 553 124.20	16 541 000	10.0	1 654 100.00
Medium	820 500	0.067	1 260 978.50	21 612 000	7.85	1 696 542.00
Steel cas	42 900	0.08	3 432.00	136 000		13 600.00
Iron cast	33 000	0.056	1 848.00	105 000	10.0	9 450.00
Pins	32 800	0.10	3 280.00	54 000	9.0	5 265.00
Bronze...	6 400	0.35	2 240.00	12 000	9.75	12 000.00
					$1.00	
Inspection (	44 333	1.20	53 199.60	43 186	1.20	51 823.00
Tot........................			$7 566 191.65	....		$8 812 146.00

plained, but the answering papers meet the plaintiff's case and destroy the inference upon which, if at all, that case is founded. The motion is, therefore, denied, with costs."

Bids for the steel towers, cables and suspended structure were finally opened on May 7th, 1906, with the results shown in Plate X.

The matter was then carried to the Board of Estimate and Apportionment on a proposition to ignore the lowest bidder and award the contract to one of the higher bidders. The battle for the construction of the bridge was taken from the courts and in a sense appealed to the arbitrament of practical politics where Gordian knots are often cut, where red tape is not as long or as strong, where technicalities are not so potent and where just decisions are often quickly reached.

The Board of Estimate at noon of Friday, June 15th, on receipt of the report of a committee which considered the matter one week voted to refer the subject to the Commissioner of Bridges for action. At 4 o'clock the same day the contract had been awarded and, at 5 o'clock, it was executed with the lowest bidder.

The successful bidder had had little, if any, experience in the construction of metal bridges. He was, however, an experienced contractor, and sub-contracted the manufacture of the steel work and its erection to some of the most experienced contractors in the country. He made the first delivery of steel on time and there is every reason to believe that he will be able to complete the entire contract at the time agreed upon, to wit: December 31st, 1909.

The land required for the approaches is now under condemnation and these approaches will be contracted for during the year 1907, so as to insure their completion by the time the bridge itself is erected over the river. Plate XI shows in diagram the progress of the work on the bridge to January 1st, 1907; the time consumed in several stages of the work and the amount of money expended in construction.

When the Manhattan Bridge was authorized, the elevated railway had not been extended to Bronx Park; the subway contract had just been executed, and it is safe to say that nine-tenths of the people fully believed that many additional miles of elevated railway would be built in the city. In consequence, the long elevated approach to Willoughby Street, in Brooklyn, was specially intended

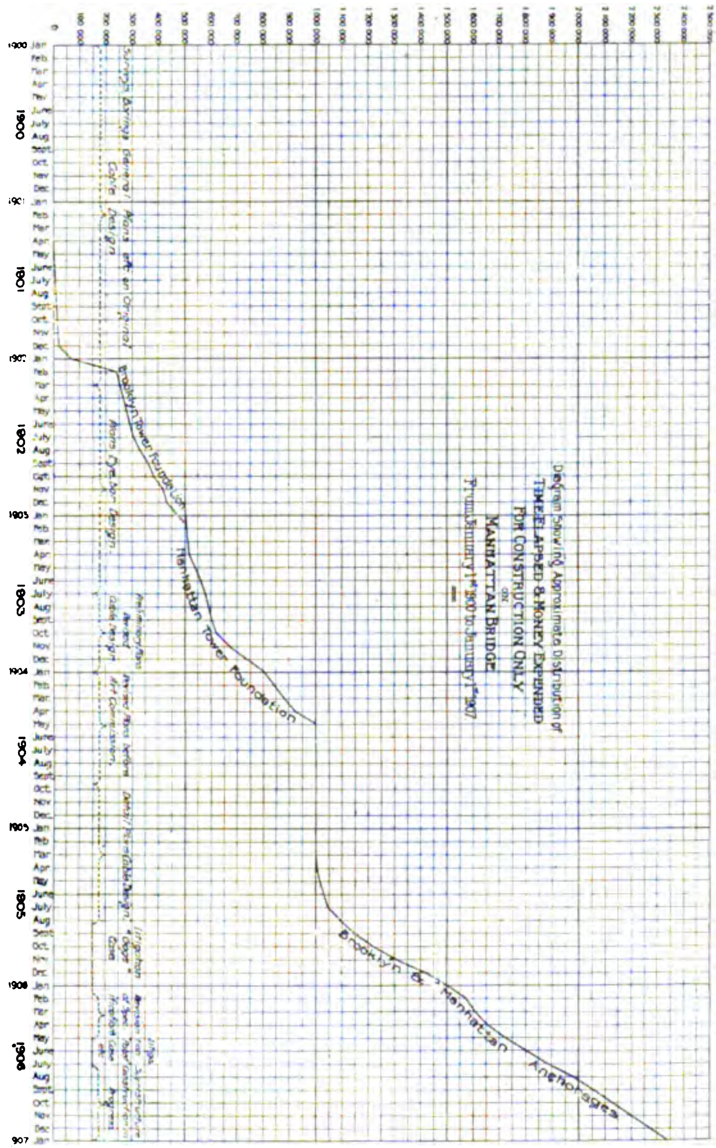
to carry the Brooklyn elevated trains to the bridge, and as late as 1903 the Commissioner of Bridges laid out an elevated railway line leading from the Manhattan end of the bridge through Canal Street to the North River. If an expression of popular sentiment should be taken to-day an equally large proportion of people would doubtless believe that no more elevated railways will be built, and that those now existing, nearly 50 miles in Manhattan and Bronx and about 30 miles in Brooklyn, will be torn down within the lives of men now in active life, and that eventually the subways will carry all those passengers who ride at good speed or for long distances in the great city.

New York has not, nor indeed, has any great city, ever kept up with the demand for transit facilities within its confines. The subways will be greatly extended and the surface lines will never be removed from our streets, and the existing elevated railways at least will always be with us, simply because we shall never be able to do without them. John A. Roebling, while expecting that the old bridge would carry less than 10 000 000 passengers per annum, said, evidently intending to anticipate a long future, that "if the proposed bridge shall possess a capacity of 40 000 000 annually these 40 000 000 will be there as sure as the bridge is built." This was less than forty years ago and to-day upwards of 120 000 000 or 3 times as many as Roebling's assumed maximum now cross the bridge yearly.

The subways are, of course, tunnels and should cross the river in tunnels. The urgency for really rapid work in transit facilities is, however, very great; tunnels are often expensive and slow to construct; there is still prejudice against river tunnels and still some doubt of the efficiency of those already constructed under the rivers; the bridges must therefore be diverted from their proper and legitimate use as highways to accommodate many of the subway routes projected for Brooklyn, which is starving for want of adequate railway connection with Manhattan.

The Manhattan Bridge was designed to carry 4 surface railway tracks on the lower deck and 4 elevated railway tracks on the upper deck. Neither surface nor elevated railways in Manhattan or Brooklyn have any franchise rights in the opposing borough and there still seems a most decided disinclination on the part of the railways in these two boroughs to remedy this defect.

PLATE XI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
NICHOLS ON THE
MANHATTAN BRIDGE.



Logically the elevated lines as well as the surface lines should be carried across the bridge and for some distance into the opposing boroughs. Many plans have been made looking to this end. The writer, in 1887, designed an "Inter-Metropolitan" railway with two tunnels across the river and several miles of underground connecting railway in the two boroughs and so arranged that all of the elevated railways in either borough could run into these subways and cross the river to the other borough. A passenger taking any train at any station on this inner-circle railway could thus go to the opposing borough without change of cars. In making the first plan for the Williamsburgh Bridge in 1891 he laid out an elevated railway approach through private property to the Bowery and through Spring Street to the North River, and subsequently suggested that this be extended in a loop to a point south of City Hall Park and thence over another new bridge to Brooklyn.

In 1905, it looked, and it still looks as though the surface and elevated railways of Brooklyn and Manhattan would be able at best merely to cross the river on the bridges and stop right there. When, therefore, it seemed advisable in that year to develop some plans for the terminals of the Manhattan Bridge just to rouse criticism and be shot at; these terminals were perforce limited to the accommodation of the railways terminating at the bridges, and the problem presented was to design such terminals with an idea of having them at least presentable from the æsthetic standpoint and capable of accommodating large crowds of people with some degree of comfort.

Although the interborough lines over the great bridge should and will at some time, in some way, extend far into both boroughs, and thousands of passengers will be carried in such a way as scarcely to realize when they pass the bridge terminals, there will always be other thousands located near one end or the other of these bridges who must take trains at the bridge terminals, and for these people good, ample and convenient local terminal stations must be built and maintained.

Of the great horde of people now crossing the Brooklyn Bridge 84% walk to the terminal on the Manhattan side, and as long as this bridge shall last, at least 50% of the people crossing it from points below Canal Street must have a local terminal station.

These local bridge terminals must be great in the broadest sense, they must permit the free transit of through trains to distant points, and they must, as well, accommodate the vast number of local passengers without crowding them into the through trains often already overloaded.

The termini designed for the Manhattan Bridge in 1905 were to a good degree of this character, and while they provided for the present conditions, they were planned with a view to the future extension of the through lines far beyond the termini of the bridge. These terminals provided for one double track subway route connecting the two boroughs, for the extension of the New York City surface railways to Brooklyn where they looped back to Manhattan; for the extension of the Brooklyn surface railways to Manhattan in the same manner, and for the extension of the Brooklyn elevated railways to a terminal in Manhattan or to a connection with the tracks of the Manhattan elevated railway. If rights for this purpose should ever be secured, the surface lines could easily extend into the other borough or the Brooklyn surface lines might be extended by subways far away into Manhattan.

The public outcry against bridge terminals killed these plans and set up other conditions which may or may not permit of equally convenient and comfortable accommodation for the public. It has at least deferred definite action on any plans, with consequent loss of time and possible embarrassment of solution, even at the time when the bridge is completed, akin to the conditions which have for many years beset the Manhattan end of the Williamsburgh Bridge.

The story of the delays and hindrances in the development of the plans for the Manhattan Bridge has lessons of great value if properly read. He who runs may read them, the iniquity, for instance, of a radical change of plans in great engineering structures with each succeeding change of political administration, and again that unnecessary and unjust, because uninformed, criticism of the acts of public officials by bodies of citizens organized for the public weal is not necessarily wise or beneficial because it claims to be virtuous. Howells, I think it is, who said, "it beats all what a man will do for an idea, especially a wrong idea."

DISCUSSION

Mr. George W. Tillson, President of the Society.—This is a subject, gentlemen, which is important both from its engineering standpoint and, also, from its material benefit both to the Boroughs of Brooklyn and Manhattan. It is, of course, of particular interest to those of us who dwell in the Borough of Brooklyn.

The speaker, in the first part of his address, spoke of the approach to this bridge from the Brooklyn side over the Flatbush Avenue extension. The depression at Tillary Street is quite a factor to be considered in laying out this approach. It is not, however, as great an obstacle as was feared it would be when the question was first brought up. Studies have been made recently by the Bureau of Highways with a view of establishing a grade on this extension that would not prove excessive. It has been found that by a fill of only 4 ft. at the greatest depression a grade can be obtained on the new street that will not exceed for a distance of 1 000 ft. the established grade on the bridge itself. It has not been considered advisable to materially increase the fill over this 4 ft. to reduce that grade, as the distance is, in round numbers, 1 000 ft., and if it were decreased even to 2½%, the grade on the bridge being practically 3%, it would entail an extra fill of 5 ft., or making a total of 9 ft. fill at Tillary Street, which would be quite a serious matter when the adjoining streets are considered, as they are all paved and solidly built up. The plan has not been entirely worked out or proposed, and, of course, not adopted; yet it does seem as if something of that kind may be brought about without any serious change in the streets in that vicinity. The character of the buildings and of the property in that locality at present are such that a change of 4 ft. would not materially damage the property, when it is considered that in order to derive the benefit from the street as a business street, as it must be, all of the present existing buildings adjoining the street will have to be torn down. This is a subject, as a whole, which has received the attention of a great many members of the Society and there must be some one who will either be glad to speak on the subject or wish to ask some questions of the speaker, who is so eminently fitted to answer any or all of them. We will be glad to hear from any one. Is there any one, gentlemen, who wishes to say anything or ask any questions?

If not, I would like to ask the speaker the size, if he remembers it, of the eye-bars that were proposed to be used in the eye-bar plan of the Manhattan Bridge. The reason I ask this is because at the last meeting of the American Society of Civil Engineers a paper was presented by Mr. Theodore Cooper on some tests that he made

on the eye-bars for the bridge now being built over the St. Lawrence River at Quebec, where the dimensions of the eye-bars, although the bridge is a cantilever type, were from 50 to 58 ft. long by 15 in. wide and from $1\frac{1}{4}$ to $2\frac{1}{16}$ in. thick.

MR. OTHNIEL F. NICHOLS, the Author.—The eye-bars for the proposed Manhattan Bridge were, I believe, to be 18 in. wide and 2 in. thick. These eye-bars were to be made of nickel steel. Nickel steel eye-bars are being made for the Blackwell's Island Bridge, which are 16 in. in width and approximately 2 in. thick, and the length is shorter than for the carbon-steel bars in the Quebec Bridge, generally not much over 45 ft.

MR. TILLSON.—What would have been the length in the Manhattan Bridge?

THE AUTHOR.—About 45 ft. for most of the bars.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 24.

PRESENTED APRIL 25TH, 1906.

THE TESTING OF MATERIALS BY THE BUREAU OF BUILDINGS FOR MANHATTAN.

BY RUDOLPH P. MILLER,* C. E., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
HORACE JOSEPH HOWE, MARTIN BERNHARDT, IRA H. WOOLSON AND THE AUTHOR.

In preparing for this topic this evening I was rather surprised myself at the extent of it; not alone the amount of testing that has already been done by the Bureau of Buildings of Manhattan, but the number of different things covered by those tests; I mean the number of different types of tests. It is more than I really had supposed. The testing work has been going on since about 1896; before that time very little had been done by the Building Department.

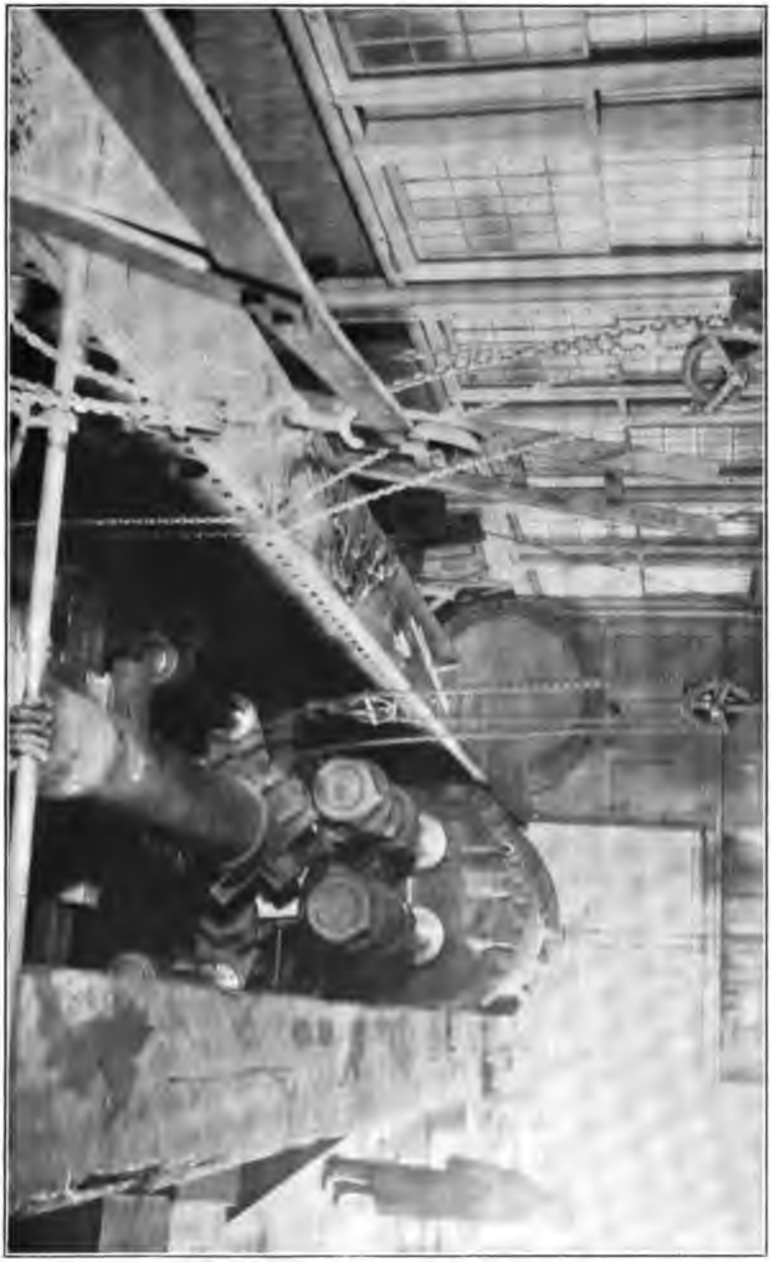
I will say nothing further about the usual cement tests than that they are made according to the standard methods of the American Society of Civil Engineers. Our Building Law at present defines what Portland and what natural cements are. The testing consists of the usual tests for fineness, strength, soundness (which test, however, is not very often made). The object of the cement test made by the Bureau of Buildings is simply to determine whether the brands of cement that are being used in the City are up to the specifications fixed by the Building Code. It is not

* Chief Engineer of Buildings for the Borough President of Manhattan.

intended to make comparative tests or determine as to just what cements will do, but simply to see that they come up to the requirements. The law requires that tests of all brands of cement that are being used in the City shall be made, and these tests are made from time to time. They do not show anything extraordinary or anything particularly interesting.

The test which we will take up next is for new materials. There are a number of materials that are recognized by the Building Code—for instance, various kind of stone, brick, cast iron, steel, and so on—but the law also makes provision for new materials, in this way: That the Superintendent is empowered to require such tests as in his judgment may be necessary for the purpose of proving any new material that may be offered and which is not covered by the present Building Code. These tests have most of them been made at Columbia University. Here is a plate of the Emory Testing Machine on which they have been made; it has a capacity of 150 000 lb. These tests consist of transverse tests on the materials, crushing test, absorption test; then we have a freezing test and a fire test. The new materials that have come up for consideration more recently have been cement brick, sand-lime brick and other cement products that are presented to us in the form of building appliances. At the time they first came up for consideration we had no definite standard and the text books gave very little satisfactory information on the subject, so the Bureau made a series of tests of its own, making an investigation of the subject and on the assumption that any new material that would come in for use should meet the requirements of our most commonly used material, a series of tests, the results of which are shown in *Engineering News*, were made on the common clay brick as delivered in our market. The brick were picked up from jobs that were going on in the City. It was intended to take the ordinary run of the product as delivered in this market and subject that to test. I will not go into the details here, but we have, first, the character of brick; then we take the breaking load, *i. e.,* supporting the brick on supports 7 in. apart, thus obtaining the breaking load, from which we determine the modulus of rupture. Then the compression test was made on one-half of the brick; the other half was soaked in water and readings were taken as to percentage of absorption at the end

PLATE XII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MILLER ON THE TESTING OF
MATERIALS.



TESTING MACHINE AT PHOENIXVILLE, SHOWING CAST-IRON COLUMN UNDER TEST.

of 30 min., at the end of 4 hr., at the end of 24 hr., at the end of 2 days, and at the end of 5 days. The brick was then taken while wet and again crushed to see if the absorption had any effect on the strength of the brick. The results seemed rather erratic; in a number of cases the brick showed greater strength after the absorption test and in other cases a very material diminution in strength, and we have not given that as much consideration, perhaps, as we ought, but the variation is so enormous, from as much as 50% diminution to, I think, 87% increase; so it appears that there must be something the matter either with the tests or there must be an unreliability in the matter of material. The freezing test consisted of submitting another half brick to alternate freezings and thawings for 20 times; then again trying its compressive strength. As a result of these tests regulations were drawn up for new materials and it was decided that the modulus of rupture in new materials should be at least an average of 450, with a minimum of 350; the compressive strength should be at least 3 000 lb. per sq. in., with no specimen falling below 2 500 lb.

This simply represents some of the results of the material submitted since, or some of it before, those regulations were fixed. I have not the time to go into details. It would take up too much time and I have more to say on the question of fire tests, which are coming up later, so I will pass that by.

In 1896-7 a number of tests were made on full size cast-iron columns. The accompanying picture represents the testing machine at the Watertown Arsenal and in it is placed a Phœnix column. That column was placed and subjected to loads in that machine for the purpose of calibrating the machine at Phœnixville, which was the machine on which the columns were tested.

We also have a plate of the machine at Phœnixville with the cast-iron column in the machine ready for test. Of course, this is not under a great load as yet. It would not be safe to stand by and look at this while it was being put under anywhere near its ultimate load.

Fourteen cast-iron columns were tested in this manner, under the supervision of the Bureau, and the results were rather startling to engineers, because it showed that we have been relying too much

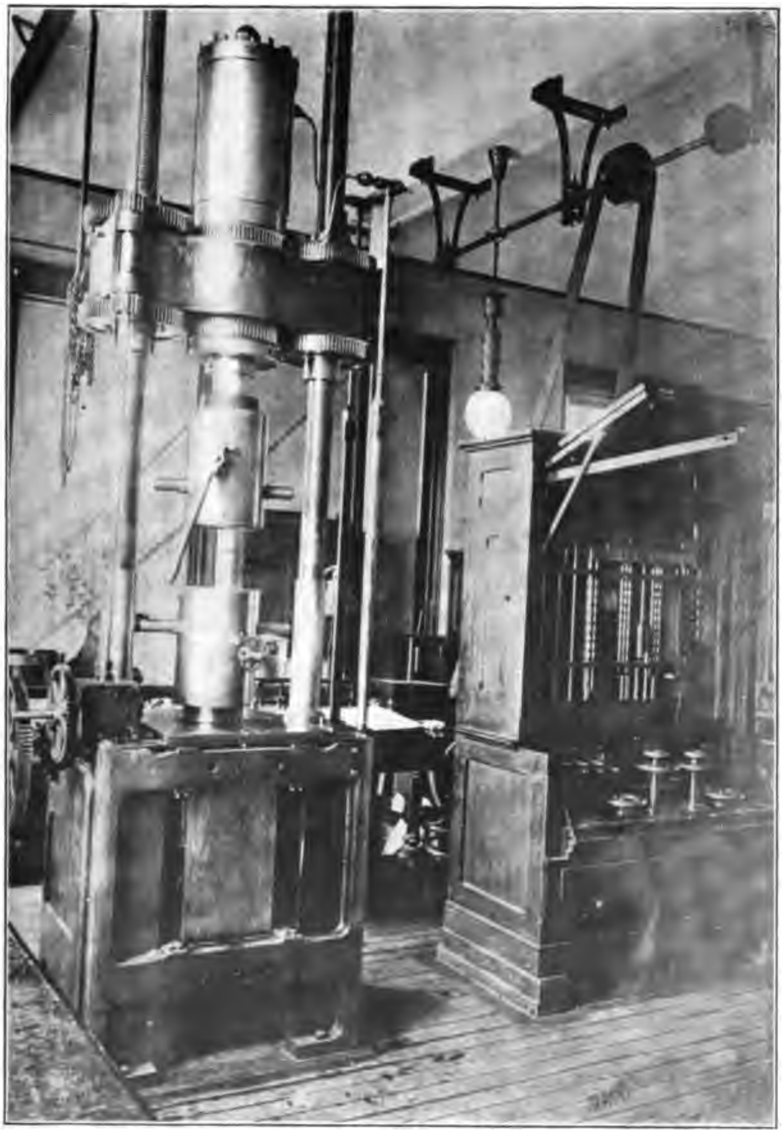
on cast iron, at least on the cast iron that was being used at that time, and it is probably the same as used to-day. The results of these tests showed an ultimate strength of these cast-iron columns of from 24 000 to about 40 000 lb. per sq. in., whereas we were figuring on an ultimate strength of about 60 000 lb.

In connection with those same tests, tests were made on cast-iron brackets to get the strength of those brackets.

Other tests that are being made by the Bureau are soil tests. The Building Code provides what loads shall be used on different kinds of soil and it makes a further provision that if greater loads than 4 tons are to be used on any soil a test must be made, or, rather, it is within the discretion of the Superintendent to allow greater loads than 4 tons per sq. ft., provided he has evidence that the soil is capable of standing greater loads. A stick of timber is set up in the lot, with a platform built on top and a load put on. We generally take a timber about 12 by 12 in., so we get just 1 sq. ft., and it is very easy to then determine the load. The load that is placed on there is about one and a half times that which it is intended to place on the soil finally, and that load must stand for 24 hr. without any appreciable settlement to be satisfactory.

An interesting test was recently made under the supervision of the Bureau. This was a load test made in a caisson. The architect's specifications called for a load test and required that the soil shall stand a load of 23 000 lb. per sq. ft. in all, or else the caissons must be carried further. The contractors had reached what they considered a satisfactory hard-pan and preparations were made for this load test. A stick of timber 12 by 12 in. was placed in the working chamber and it was cut down to 8 by 8 in. in size. That brought a very severe test on the earth, because you have a wedge effect, but they tried it, building a platform over the end of the timber and put on pig iron. It was just about all they could do to get pig iron in there to get a satisfactory loading, but the load that was secured was about 12 tons to the square foot. Of course, the stick was only 64 sq. in. at the base, so the total load, I think, was 10 300 lb., or thereabouts, but it brought the required load per square foot on that soil and there was no appreciable deflection, not even from the time the test was started until the load was entirely on it. Not only were readings taken inside to see whether there

PLATE XIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MILLER ON THE TESTING OF
MATERIALS.



Emory Testing Machine at Columbia University.

was any settlement, but check levels were taken on the top of the caisson to see whether there was any movement in the caisson itself.

We also are called upon to make tests on piles. The law prescribes the formula by which the load on ordinary wood piles shall be figured, in case there is any doubt, by using a blow of the hammer, the usual formula; I think it is known as the *Engineering News* formula. But there is the case of a concrete pile, for which the law made no provision, and here the load was simply placed on top of the pile, a load of 45 tons—it was really higher than that—for a pile which was supposed to carry 30 tons. There was, after that stood for 24 hr., no appreciable settlement.

The principal testing work, though, of the Bureau has been along lines of fire-proof materials. The law prescribes what constructions, in the way of fire-proof floors, can be placed in buildings, *i. e.,* brick arches, terra-cotta arches and concrete arches, when complying with certain conditions. Then it goes on to say, "or other materials," concrete, terra cotta or other compositions reinforced in any manner may be used, but, before approval, a fire test shall be made; and it then prescribes what that fire test is.

One of the commonly used floors is a cinder-concrete slab, reinforced with 2 or 3-in. flat bars, spaced about 16-in. centers.

Then there is the terra-cotta arch. The law prescribes that the depth shall be 1¾ in. for each foot span, so you can readily see for a 7-ft. 6-in. span we get nearly a 14-in. block.

There is a form of terra-cotta arch with a reinforcement of a metal truss work, placed in joints. All these floors have been submitted to a regular fire test and approved.

For the purpose of making these tests a test structure is erected. The illustration gives a fairly good idea of the test structure. (See Plate XIV, Figs. 1 and 2.)

The structure is built of brick walls, or concrete walls; any satisfactory construction that will hold the floor to be tested and will hold fire at the same time. A grate is placed about 2½ ft. above the ground. Draught openings are placed in the lower part under the grate and chimneys are placed at the corners at different points so as to secure the necessary draught. The construction to be tested then forms a roof of the test structure and a fire is built inside and maintained for 4 hours. The temperatures of that fire are

read by pyrometers placed in the chamber immediately under the floor and the readings are taken about every 2½ or 5 min. and they are afterwards plotted. An attempt is made to get the temperature up to 1 700° fahr. within the first half hour and then maintain it at that point or somewhere near it, so that an average temperature of 1 700° fahr. is obtained for 4 hours. The law requires that temperature.

After the 4 hr. of fire a hose stream is applied to the under side of the floor at 60-lb. nozzle pressure through a 1⅛-in. nozzle for 5 min. The top of the floor is then flooded and then a hose stream applied again on the under side for another 5 min., so that you get a pretty severe application of water after you have had the fire. The floor, while it is being tested, is loaded with a uniformly distributed load of 150 lb. per sq. ft. That load is afterwards increased to 600 lb. per sq. ft. over the entire surface, and the requirements are that during that test no water or fire shall pass through that floor and it shall at the same time safely maintain that load, and that the permanent deflection, after the entire removal of the load, shall not be more than 2½ in.

In the test structure you have the beams running across it. I might add that the law requires that these beams shall have a clear span of 14 ft. and the beam must properly support the load of 150 lb. per sq. ft. Rods are placed, three on each beam and one in the center of the slab and the deflections at those points are read by means of the level on the stand. The level readings and the deflections during the test and the deflections afterwards with the 600-lb. load on, and when the final load is removed, are obtained. Another method, devised by Prof. Woolson, of Columbia, who has conducted a great many of these tests for the Department, indicates graphically these deflections. The original beam lines are shown by straight lines, then dotted lines indicate the deflections.

Cinder-concrete floors have been tested. Of course, the beams are all encased. The water washes out some of the cinder-concrete, but these tests which have been made thus far—and I think we have made about thirty-five or thirty-seven tests on cinder-concrete constructions—show that cinder-concrete is probably the most satisfactory fire-proof material we have.

The important element in fire-proof construction is the protection of the metal which gives the strength to the construction.

FIG. 1.—TEST STRUCTURE FOR TESTING FIREPROOF FLOOR.

FIG. 2.—UNSATISFACTORY REINFORCED CONCRETE CONSTRUCTION AFTER FIRE TEST.

A terra cotta floor construction, which was subjected to the fire test showed a fairly good result, but a long piece of the beam protection came off. That is one of the weaknesses of the terra cotta construction. The lower webs are liable to scale off, but the terra cotta stands the fire test quite satisfactorily.

In the test structure, the walls of which were made of cinder-concrete mixed in the proportion of one part of Portland cement, two parts of sand and five parts of cinders, the load was carried safely and it went through, I think, four or possibly five fire tests and the walls were practically as good at the end of the last test as they were when they were built. In these tests it is very common, in both brick and stone concrete structures, to have the outside crack very badly. The cracks close up again after the test is over and the structure cools off. It shows that the material, that is, the brick or stone concrete, being a very poor conductor, expands at the inside, where the heat is, and tears apart on the outside, where it is comparatively cool. Now, cinder concrete seems to have more elasticity in that respect and holds together; it transmits the heat, though, rather more rapidly.

We have been speaking chiefly now of the cinder-concrete constructions. About fourteen tests made by the Bureau have been on stone concrete and have been on what is a pure reinforced concrete; it is not steel construction encased or filled in between with a fire-proof filling, but is a stone concrete reinforced with metal.

The effect of fire generally on reinforced concrete is to scale off the concrete to a depth of at least 1 in., so it is necessary to bury the reinforcing members to a greater extent than that in order to thoroughly protect them against the heat. The water, of course, does the damage in this way: that the fire breaks up, or disintegrates the concrete on the surface, and the water washes it off.

In the illustration, we show an unsatisfactory result. (See Plate XIV, Fig. 2.) Of those fourteen tests on reinforced concrete fire tests made under the supervision of the Bureau only seven of them have proved entirely satisfactory. Of course this is one of the worst cases. The failures are not all as bad as that, but it shows that we do not know all we want to know about stone concrete as to its fire-proof character. Just why this failed we have not been quite able to determine, but there seems to be the uncombined

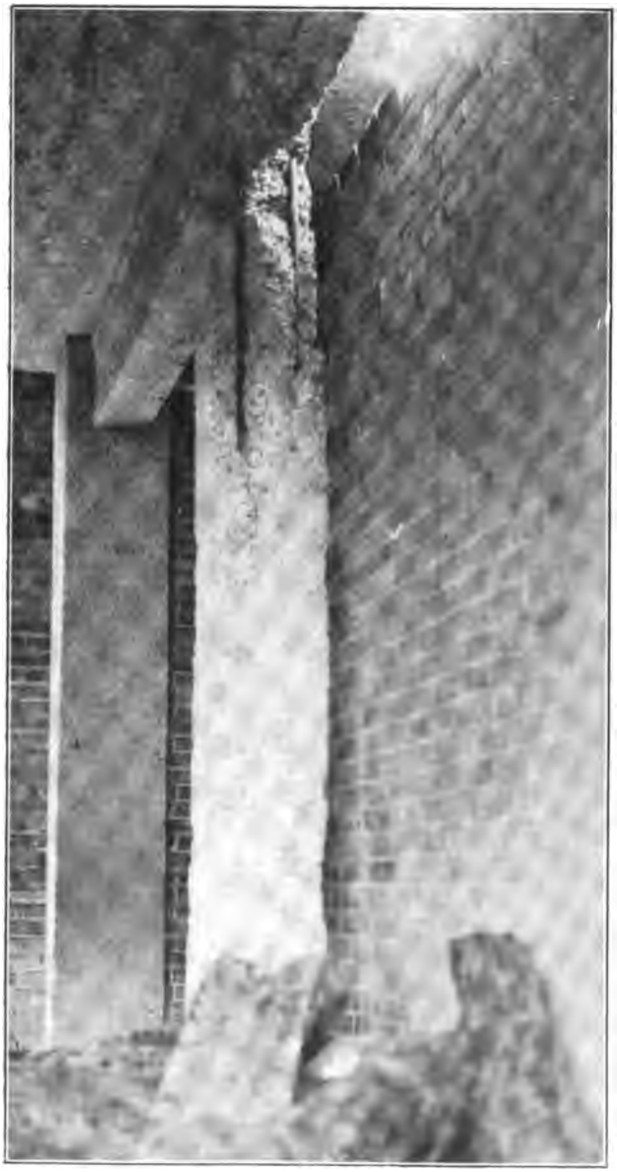
water in the concrete that is mostly responsible for it. We find that, if we make a test of cinder concrete after construction, before the concrete has been able to take up all its water, the result is more liable to be a failure, but there are other things which must also be considered. We have reason to believe that if a limestone is used in concrete it is liable to crack and swell off, expose the metal and in that way result in failure.

The column plate shows you the result on a column in one of the tests. The column is rather a vulnerable construction; the corners are very liable to come off and, of course, then you begin to expose your reinforcement to the danger of the conflagration.

After a construction has been approved as fire-proof, when the approval is given, it is for a live load of 150 lb. to the square foot and nothing greater. If the floors are intended to carry greater loads, then load tests must be made to demonstrate that they will do that. In that case we require that the test load shall be ten times the final approved load. In the fire test you will notice the factor of safety is apparently only 4. It is really more, because in the fire test the structure must carry that load of 600 lb. per sq. ft. safely during the test and must recover sufficiently so that the beams have not any serious deflection. In determining the carrying capacity in construction we load it to ten times. We load it up until it breaks, then take one-tenth of the breaking load as the working load. We are sometimes called upon to make tests in buildings for the purpose of demonstrating either to the owner or architect that the floors are capable of sustaining the loads that they are designed for. Criticism is often made in this method of testing floors that in the loading up, piling it up on the floor, there is an arching effect. You can pile up material so that you will get the arching effect and relieve the floor to that extent, but I doubt very much whether there is sufficient arching in any of our methods to relieve any part of the loaded area.

Another method of making these load tests that has been used, but which has not been considered very satisfactory, is the one in which a long I-beam was taken, held down at the far end, supported over a knife edge on the floor itself, the load being distributed by a little plank of wood laid on a bed of sand at the center of the floor to be tested. At about one-tenth, or ten times the distance

PLATE XV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MILLER ON THE TESTING OF
MATERIALS.



REINFORCED CONCRETE COLUMN AFTER FIRE TEST.

from that fulcrum, a platform was hung and sand was measured out and put in on this at about 100 lb. at a time. The sand was carefully weighed, so that we could readily determine what this load was. There are several objections to this form of testing. One of them is that your load is a concentrated load. Of course, you can double that load and get the equivalent uniformly distributed load, but you do not get the effect of the shear. You see your shear on the ends is just one-half of what it would be if you had a uniformly distributed load. Another difficulty was found, in dropping the sand on, that the little impact due to that sand, no matter how lightly you placed it on that platform, produced an enormous shock, so that the construction really fell before the load actually was placed.

There is another method that was used some years ago, but has not been used since. It is simply a jack supported by a long I-beam passing down at each end and the pressure put down on the floor at the center by hydraulic pressure and gauges placed to relieve the loads.

Another material that is tested by the Bureau is the material used for partition constructions, dumb-waiters, elevator shafts and similar details in fire-proof buildings, and for that purpose the material is subjected to a test. A structure of this kind, in which the side panels are about 9 ft. 6 in. high and about 14 ft. long, is erected and a fire built in that, the fire being maintained at a temperature of 1 700° fahr. for the second half of an hour. The test lasts just 1 hr. The first half is taken up in raising the temperature from that of the air to 1 700°, and the second half hour in maintaining it at about 1 700°. The temperatures are read by means of a pyrometer.

The test structure in general is about the same as for the floor test, having a grate about 2½ ft. above the floor, the structure itself being about 9 ft. high; the roof is of any material that will hold together during the test.

The diagram shows a typical temperature diagram of a partition test. You have the temperature rising pretty gradually for the first half hour and then kept at about 1 700° fahr. in the latter half of the test. (See Plate XVI.)

After the fire test, water is applied, but not at the same pressure

in this case as in the floor test; ordinary hydrant pressure is used; that is supposed to be about 30 lb. at the nozzle, and the hose stream is played against this partition for 5 min. and the requirement is that no water or fire shall pass through that partition during that test, and that it shall not unduly bulge or warp, or otherwise show signs of failure.

Terra-cotta constructions have always stood pretty well in the fire test. The plastering placed on the walls usually drops off. That is the case in nearly all our fire-tests where plastering has been applied in the floors as well as in the partitions. The plastering comes off in about 20 min.

A metal lath and plaster partition construction stood the test, but the water washed off considerable of the plaster. That is generally the case in a metal lath and plaster construction also.

A test was made on plaster block construction. These blocks were on the one side of the test structure, 2-in. solid plaster blocks; on the other they were 3-in. blocks, but had air spaces in them, and both sides stood up equally well.

In the case of the failure of a plaster block partition, the failure was probably due to weak construction; the material was not responsible for it, but the weakness was in the joints; the joints were small and a large number of them. In other cases where they simply try to lay up the blocks without some fastening between them it is liable to result in failure and has resulted in failure. Generally, in a great many of the constructions little dowels are used from one block into the other, or grooves are made—a tongue-and-groove arrangement in the blocks, or else grooves in both blocks and the joint filled up with cement or something of that kind. If you make some such provision, a plaster block will probably stand the fire test very satisfactorily.

Another type of construction which has received the attention of the Bureau is "fire shutters," "fire doors" and "fire windows." A test structure is erected for that purpose, and in this test structure, on each side of the structure, is placed either a window or a door, with a fire-proof shutter. The fire is built not only on the inside, but also on the outside, so that you have fires on both sides. In making this test, the fire is kept up for 1 hr. under about the same conditions as in the partition test.

PLATE XVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
MILLER ON THE TESTING OF
MATERIALS.

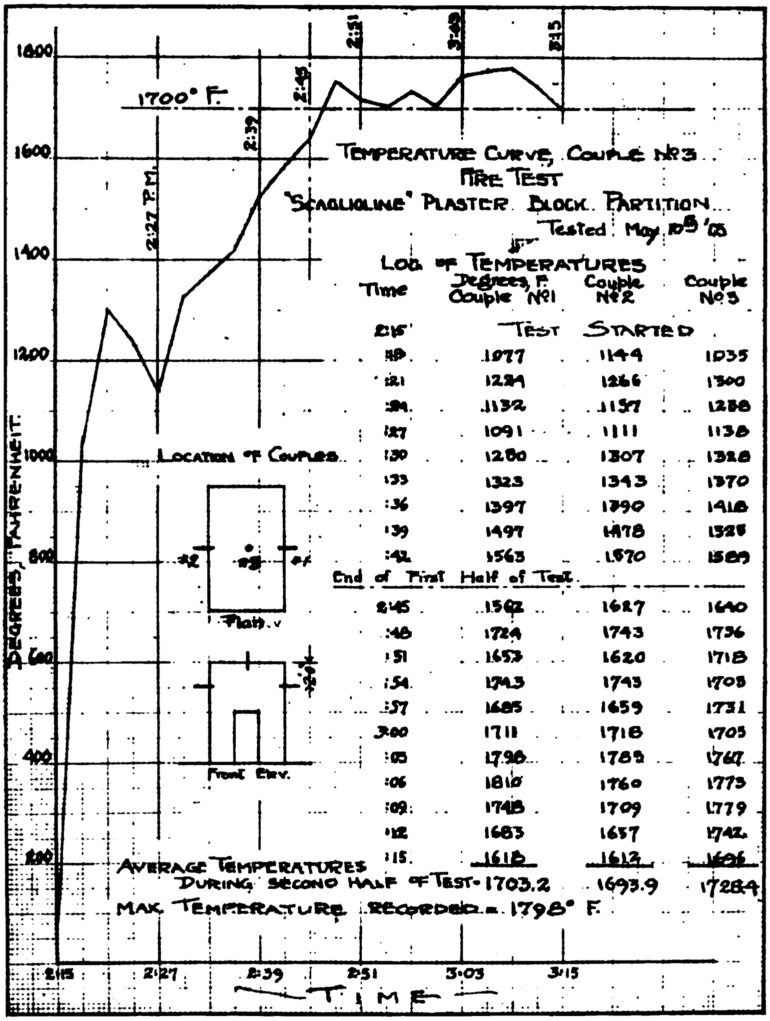


DIAGRAM SHOWING TEMPERATURE DURING FIRE TEST ON PARTITION.

In one of those tests on a tin-covered wood door, the door held the fire satisfactorily, but with the result that when it was opened afterward they found the wood thoroughly charred inside, but if the door succeeds in confining the fire for ½ hr. or more it has practically served its purpose. You cannot expect much more from a fire-proof door or shutter.

In another type of door, known as the "Kalamein" door, the metal is drawn over the wood. It shows you very good results and in actual fires these doors have done very good service. The first mentioned door is what the underwriters prefer. It is made of seasoned pine wood and covered with tin, with lap seams, but no solder, and nailed under the seams.

In tests on wire-glass windows, if the panes are not made too large, they will crack and warp slightly, but they will hold. If they are made large, they will drop out of the frames, with the result of failure. The underwriters prescribe that those panes shall not be more than about, I think, 5 sq. ft. for the largest, and the frames in these wire-glass windows generally are hollow metal frames, which are preferred by the underwriters, or they may be of wood covered with metal, the same as the "Kalamein" process.

Another line of investigation that was undertaken by the Bureau was column coverings. A column in a fire-proof building is a very important element, and, unless that is taken care of, serious consequences will follow. Some tests that were made at Long Island City, I think about 10 years ago, on metal columns, steel columns and cast-iron columns, showed that a column begins to lose its strength when the temperature reaches 1 100° fahr. For that reason we consider that we should never go much beyond 550° in metal, and these tests were devised because we could not get the necessary facilities or appropriation to make tests on full-sized columns, properly protected, so that the test was made in the following way: A cast-iron plate 12 by 12 in. was taken and covered on one side with the material that was to be tested, which was thoroughly secured to this metal plate. A hole was bored into the metal plate to within about ⅛ in. of the surface, against which the material was placed, and a thermometer was let down into that hole. The test piece was then set over a crucible furnace and kept there for 2 hr. The temperatures were read by pyrometers

placed immediately under the specimen and maintained at about 1 700° fahr. for 1 hr. and 40 min., the first 20 min. being taken in raising the specimen from the temperature of the water to 1 700° fahr.

In the case of tests on plaster block composition, after the test specimen was removed from the furnace it was placed under a hydrant, and the water, under ordinary pressure, applied to see what the effect would be. The effect, in the case of the plaster block, was simply to wash away a good deal of the material. The block was found in pretty good shape after the fire; of course, calcined more or less, and then the water washes the material away.

The porous terra-cotta blocks 2 in. thick, which were subjected to a similar test, kept quite sound.

Another type of construction which was tested was metal lath and plaster, the metal lath being placed practically against the cast-iron plate and the plastering. This was a hard-finished plaster put over it and a white finish put on top of it. The white finish practically disappeared, but the hard finish remained there.

I might say that in all cases 2-in. thickness is used, or we try to get 2 in., which is what the law required for the protection of the column. A composition known as Lignolith did not show off quite so well as the plaster compositions. Cinder concrete and terra cotta were not far apart; they gave about the same results. The temperature in these cases never reached 200° fahr. The highest of them all, a cinder-concrete slab that was only 1½ in. thick, was one that had been used in a building in New York, and we thought we would like to try and see what the result would be with only 1½ in. thickness, and even in that case the temperature never reached 400° in the metal slab. This shows that the plaster is probably the best non-conductor of the materials that are used, but the trouble with plaster is that it will wash away so readily when the water is applied.

Another material that is tested, and which we are in a way compelled to test by law, is fire-proof wood. The law requires that all buildings over twelve stories in height, or over 150 ft. in height, shall have all flooring, if wood is used, treated by some process to render the wood fire-proof. For the purpose of determining whether

the wood is fire-proof we make certain tests. One of the first tests proposed for this purpose, which was used by the United States Government, was what was known as the "shavings test." A metal pan is taken which has a wire-mesh bottom, and in that shavings of the wood to be tested are placed, *i. e.*, placed about half full, and then a Bunsen burner is placed under this and the flame kept there about 25 sec. Then it is withdrawn and the results noted. The amount of material that is consumed is noted and whether the flame continues to spread or not. The test is not considered entirely satisfactory because it depends so much on the man who makes the test. By having the shavings a little tighter in one case than another, he can very materially affect the results, so that the results are not always satisfactory. For that purpose Prof. Woolson has devised a test which is generally used now, known as a "timber" test.

For this test the crucible furnace is used. The wood specimens are placed across the top and kept there for 2 min. and the results are noted. The wood chars and perhaps even flames. After the specimen is removed from this furnace the time is noted of the continuance of the flame and also of the continuance of the burning, and then when that has all disappeared the specimen is cut across the middle and the charred portion scraped away and the area measured and compared with the original cross-section. By this means we have a means of measuring the effect of heat on this fire-proof wood and it is perhaps the best system devised for comparative purposes.

For ordinary soft woods the best treatment we get nowadays gives a reduction of area sometimes as much as 70%. We do not accept that for the harder woods. With them you ought not to get more than 45% reduction. The flame and burning ought to disappear in 20 sec. after the specimen is removed from the furnace.

There are some other tests that are made by the Bureau on materials that are to take the place of fire-proof wood. These are made very much in the same way that the tests on the column coverings are made, only that the time is not so long. They are only subjected to the furnace for 30 min.

We have also made fire-tests on roofing materials, but I have nothing of value to show, and there is nothing of particular interest in them.

DISCUSSION.

MR. G. W. TILLSON.—I think, gentlemen, that the paper that we have just heard illustrates, more fully than any that has ever been presented to this Society, the real value of the Society; and that is, to teach the different Departments of the City what is being done in the other Departments. The Department of Buildings is one of the most important in the City. It is one, too, I presume, that has as few men—technical men, engineering men, or men who are eligible for this Society—as any other Department in the City, and I think the paper that we have just heard is one of the most important, from its intrinsic merit, of any that we have had, as it gives us not only a knowledge of what is going on in the Department of Buildings, but it gives us a great deal of information that is not only of interest to hear, but cannot help being of great value in the future, and I take great pleasure in presenting this subject for discussion to the Society. We will be glad to hear from anyone, either on new discussion or questions to Mr. Miller on anything that he has said.

MR. H. J. HOWE.—I want to say that the paper shows one branch of engineering different from the time that I went to school, and that is that it relies on full-size tests. When I studied my first text books I was filled up with a lot of names, Jerguson and others, that, as I look back, seem very large in my memory. They were made up on the basis of small-size tests, not only of steel, iron and other metals, but of wood, etc. It seems to me that we ought to appreciate this paper, and we ought to know now and then of men advanced in engineering in that particular. The Watertown tests, of course, we are familiar with, and another test to-night we have had in the same direction. I would like to ask Mr. Miller for the details about the concrete pile, the simplest pile that he referred to; 45 tons I think he said it was for a 16-in. What was the condition of it? Was it a separate pile, or did it go down to the solid rock, or was it pressed in the soil, and anything that he may think of.

MR. R. P. MILLER.—The "Simplex"—I suppose you are acquainted with the type of the pile—is a steel tube driven with a point or shoe into the ground just as far as it can be driven; in this case the one we showed was for a building at the corner of Broadway and Beaver Street, the Produce Exchange Bank, and the piles were driven about 30 ft. and were supposed to have struck hard-pan. The tube was filled up with concrete and I think it was 16 in. in diameter. We calculate that it should carry about 30 tons without unusual settlement. I don't know that there is anything further.

Mr. H. J. Howe.—Was it reinforced?

Mr. R. P. Miller.—No, it was simply the concrete filled in this steel shell.

Mr. H. J. Howe.—And the shell left there?

Mr. R. P. Miller.—No, the shell was withdrawn. The shoe remains, but the shell is withdrawn. The tube is driven and then it is withdrawn for a certain distance and a bucket of concrete let down and deposited; then the shell is drawn a little further until another bucket is filled in, so that your concrete really fills the space that the tube occupied in the end and you have really a plain concrete pile.

Mr. G. W. Tillson.—Any other discussion, gentlemen?

Mr. Martin Bernhardt, Jr.—I would like to inquire whether cinder concrete is a safe construction for chimneys in frame buildings?

Mr. R. P. Miller.—I don't know. So far as their safety against fire is concerned I say unhesitatingly "Yes," but I would not like to say so because I think they would transmit more heat probably than the brick. I think they would not be as satisfactory a protection because of the porosity of the cinder concrete, and yet cinder concrete does not, as shown in those little tests we made for column coverings, transmit a great deal of heat at that.

Mr. G. W. Tillson.—The gentleman who first spoke mentioned an important principle, that of making full-size tests,—so that the conditions of testing will conform as nearly as possible to that obtained in actual construction. It, of course, is a very difficult thing in a great many cases, but the work of all testing laboratories at the present time is, I think, tending very rapidly in that direction, and the importance of it cannot be overestimated, because in large constructions that are going on at the present time we want to deal with facts and not with theories.

I understand that Prof. Woolson, who has made many of the tests that are referred to in the paper, is present and I presume that every one in the room who has had anything to do with materials that have been tested has had something to do with Prof. Woolson's results, and I know the Society, as well as myself, would be very glad to hear from him this evening.

Prof. Ira H. Woolson.—Mr. Chairman: You take me a little bit by surprise, because I did not come to talk, but to listen. I assure you that I have been immensely interested in the talk of the evening by Mr. Miller and was particularly pleased with the very lucid and systematic way in which he presented his subject. He has followed the various tests through with a completeness

which is very satisfactory for the short length of time which he had to devote to his topic.

I have now been testing, or taking large work under the direction of the Bureau of Buildings in the testing line, for a number of years, running back through the administration of some half a dozen or more Building Superintendents in the Borough of Manhattan, and it gives me pleasure at this time to make public this statement: That in all that time the work which has been carried on directly under the Engineering Department of the Bureau of Buildings has been made in the most thorough, conscientious and honest way that I can conceive of. In no respect, in any way whatever, has there been any deviation from a true scientific result, and whatever may be said in criticism of the Department, which we hear from time to time and see in the newspapers in regard to its regulations and its work, as all Departments are subject to those criticisms, I can say this: That there can be no criticism of that kind in regard to the testing work with which I have had anything to do, or have known anything about, that has passed through the Engineering Department nearly all of the time, if not all of the time, under the supervision of Mr. Miller. It is very gratifying to work with a Department in which work is carried on in that conscientious and scientific manner. I think the results which have been obtained by the Department in that length of time speak for themselves, as regards the value of that kind of testing work.

I don't know that there is anything I can add. It seems to me Mr. Miller has covered the ground very thoroughly. I want to voice the sentiment of one of the previous speakers and also of the Chair this evening in regard to the advisability and the great desirability of making testing work on full-size members; no matter what the work is, whether strength tests, fire tests, or whatever the work may be, test them on units large enough to get some satisfactory information regarding the unit as a whole and not attempt, as they did in the earlier days, when they were compelled to do that for lack of machines and appliances, to differentiate from small test specimens to very large ones.

I think the example that the speaker this evening called attention to in regard to the tests of cast-iron columns illustrated that point very nicely. The old factors that were used in calculating the strength of cast-iron columns were based upon the tests of small specimens of cast iron and then from those small tests calculated what a large, full-size member should stand. When opportunity came and those large members were tested, as he illustrated to-night, it was found that those conclusions were entirely erroneous by a very large percentage. The tendency is, as the Chair stated

to-night, that all testing laboratories are making their facilities such that they can test large-size members. It has been one of our regrets at Columbia for a number of years that we had only a 150 000-lb. machine to operate on that kind of work, but it is my pleasure to state that during the summer we expect to put in a 400 000-lb. machine, which will be a very decided addition, particularly at this time, when there is a strong tide toward concrete construction where we must necessarily test moderately large units, and particularly in the line of concrete blocks, building blocks and structures of that character, where we need large units. I know of at least two laboratories in the country where they are putting in 600 000-lb. machines. Those are very desirable and I wish we could have one at Columbia, but we have not the space to put it in, as it requires a good deal of head-room in order to put in a machine of that large type.

I don't know as there is anything further to say.

Mr. G. W. Tillson.—I think the gentlemen will all agree that Prof. Woolson is as good a speaker as he is a listener.

While, perhaps, it has no engineering value, when the speaker showed his tests on the fire-proof wood, it called to mind a story that was told to me a short time ago by an architect, of an experience that occurred when the fire-proof wood was first used. The carpenters in the building, as was often their custom, the first one or two days carried home some of the shavings and the odd pieces of wood for kindling. They did not do that a great while and in a short time there was quite an accumulation of this waste material, and after it had reached quite large proportions the builder sent a load of it to the dump. When the man was quite near the dump he was met by a man on the sidewalk who wanted to know what he was going to do with that wood. He said: "Haul it to the dump." "Don't do that, I will give you a dollar for it for kindling." The load was pretty large and the driver was thrifty and he said: "No, you can't have it for $1.00, but you can have it for $2.00." And after some hankering he sold him the fire-proof wood for kindling.

Is there anyone else who would like to discuss the question, or ask any questions?

Adjourned.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 25.

PRESENTED MAY 23, 1906.

RECENT DEVELOPMENTS IN WOOD BLOCK PAVING.

BY FREDERICK A. KUMMER, ESQ.*

WITH DISCUSSION BY
EDWIN H. THOMES, WALTER G. ELIOT, MAX L. BLUM, WISNER MARTIN, DENNIS FARRELL, SAMUEL C. THOMPSON
AND THE AUTHOR.

It has been my good fortune during the past eight or nine years spent in the manufacture and laying of paving material to have had the privilege on many occasions to address representative gatherings of engineers on the subject of wood block pavements; in fact, I came to the conclusion a year or two ago that the time had arrived when the pavements themselves could speak more eloquently in their favor than I could, but in the course of their development, as is the case in the development of all things, I have been frequently obliged to revise my opinions regarding many of the problems which this development presented, and therefore it may be of interest to you to have me tell you about some of these problems and the methods which have been used to overcome them.

It is with feelings very different from those with which I read my first paper on this subject before the American Society of Civil Engineers in the year 1900 that I address you to-night. In those days the man who approached the average municipal engineer with a proposition to lay wood block was regarded very much as the

* Engineer for the United States Wood Preserving Company.

average business man would regard a dealer in gold bricks; and even the journal which we all regard with so much admiration, *The Engineering News,* took occasion, in an editorial, to point out that the introduction of wood block pavements in the United States would prove a very hard row to hoe, with little prospect of success. To-day the most famous street in the world is being laid with wood block, and it would appear that the pavement had so demonstrated its good qualities that it has come to stay.

Without entering very deeply into the general question of the manufacturing and laying of wood blocks, with which you are doubtless more or less familiar, I would say that in the inception of the wood block idea in the East there existed two sources of information and experience upon which the engineer could draw in his efforts to find the best. One of these lay in English and continental cities where wood block had been successfully laid for many years upon streets of the heaviest travel. Engineers and laymen speaking of these pavements, as a rule, referred to three general conditions: First, that the English pavements were better because they were laid on excessively heavy concrete foundations, running in some instances up to 12 in. in depth. This statement I have had made to me within the past month by the Mayor of a large and progressive city, and yet it is certainly the better engineering construction to lay foundations of no greater depth than the conditions require, and if 4 in. or 5 in. or 6 in. of concrete is amply sufficient to carry the loads passing over the street, what could be gained by increasing the concrete depth and also the price of the pavement to no purpose? It therefore became apparent that wood pavement required no greater depth of concrete than any other form of pavement, and that this depth in accordance with the practice of most American cities was quite sufficient for the purpose at hand.

The second prominent feature which was brought forward in connection with the foreign pavements was the use of hard woods from Australia, known as the Karri and Jarrah woods. It was found upon investigation that these woods were by no means used in the majority of instances abroad, that they were laid untreated, were open to the serious objection of at least a portion of the blocks decaying, and made a paving surface so hard and slippery that horses with difficulty obtained a foothold on them, unless the pave-

ment was constantly sprinkled with sand or crushed stone. On the other hand, the laying of such soft woods as Norway pine, either dipped in creosote oil or treated with about 10 lb. to the cubic foot, did not seem to be a scientific solution of the wood-paving problem, and it became evident that better results would be obtained from long-leaf yellow pine, which, while harder than the Norway pines, is still not so hard as to be unduly slippery and is susceptible of complete treatment with preservative material, by which is meant a treatment throughout the entire mass of the block.

The third fact which an investigation of these pavements brought forth was that the blocks were almost universally laid with a joint of from ½ to ¾ in. between them. Why this practice was adopted I do not know, unless it was with the idea of allowing untreated or insufficiently treated blocks to expand, but this could hardly have been the case, because these joints and the surface of the pavement itself was so liberally filled and covered with paving pitch and gravel that the resulting pavement resembled very much a tarred roof through which no water could readily penetrate. This method of laying the block, especially with Australian woods, provided a better foothold for horses, because the joints of the block rounded off under travel, producing a sort of cobblestone effect. This method of laying was also discarded in investigating the subject, and it was decided to lay long-leaf yellow pine blocks, thoroughly treated throughout, on a concrete bed of moderate depth, with tight joints, the block being so filled with a preservative material, that water could not enter and cause expansion, and for this reason no joint was used between the blocks other than fine, dry sand. It was also thought, and events have proven it correctly, that the rate of wear of Georgia pine properly treated was so small from year to year that blocks of a moderate depth of 4 in. would be sufficient for the most extreme conditions, and this has since been reduced to 3½ in., and in some instances 3 in. The English practice, on the other hand, was to use blocks 5 to 6 in. deep, and in some cases even more. It is with some satisfaction that we note that the English practice is now being modified, tending to the use of a shallower block laid with tight joints.

After securing this information from the foreign practice, the laying of wood block in the western part of the United States,

notably at Indianapolis, was looked into, and here it was found, while Georgia pine blocks on 6 in. of concrete, 4 in. deep and laid with tight joints, were successfully resisting wear, they had in many instances swelled badly and were almost universally laid with a heavy pitch expansion joint along the curb to obviate this difficulty. The absorption of water by these blocks was due to two causes: First, insufficient treatment, and, second, treatment with ordinary commercial creosote oil. This, it was believed, could be remedied by increasing the amount of treatment from 12 to 14 lb. per cu. ft. to 22, and combining with the creosote oil some highly waterproof material, such as melted rosin, to seal up the pores of the wood and prevent both the absorption of moisture and the leaching out of the oil. It was on this basis that wood block pavements in the East were first laid, and their success was very great.

We now come to some of the problems which have complicated the question in recent years to such an extent that unless they can be solved the use of wood pavements could hardly be very extensive. These problems were partly of a commercial and partly of a technical nature. They involved, first, the increasing price and the decreasing quality of the long-leaf yellow pine available for the manufacture of paving blocks. Second, the enormous increase, amounting to several hundred per cent., in the cost of rosin. These are both commercial questions, but they brought in their train a very large number of technical questions, the solution of which has not been easy. Ten years ago the average manufacturer of long-leaf yellow pine in the South would use every effort to obtain an order for 1 000 000 ft. or 2 000 000 ft. or more of all-heart, long-leaf yellow pine, cut from the best part of the tree and of very superior quality. To-day there is not a lumber manufacturer in the United States to my knowledge who would accept such an order, and only at very high prices can lumber of good quality be secured. It is a well-known fact, for instance, that the density of yellow pine between the lower and upper parts of the tree varies as much as 30%, and yet to-day the lower and larger parts of the tree are being used for large-sized timbers, while the smaller and less dense parts are being cut into paving-block stock or material of a similar small dimension. Then, too, the exclusion of sap wood in the lumber has become and is daily becoming more and more difficult. These conditions would

result either in the production of a paving block so costly that it could only be used on the most heavily traveled and luxurious streets, or in the production of a block which would be inferior in quality. Neither of these results were in any way desirable, and it therefore seemed evident that manufacturers of paving block must find a substitute for long-leaf yellow pine to avoid these conditions. The United States Government has also taken a very lively interest in this question, and through their suggestions, as well as through those from other sources, it was concluded that one of the gum woods, existing largely in the South and known as black gum, possessed all the requirements for successful use as a paving material. This wood, on account of the difficulty in preventing it from warping, and other inherent qualities, has been used very slightly for general purposes. It resembles the Australian hard woods above referred to, but, while very dense in grain and tough, is not so hard as those woods and not so proof against decay. It was felt, however, that, properly treated, it would make a block, if anything, superior to Georgia pine, and actual tests in service indicate this to be the case. Blocks of this character have been laid for somewhat less than a year on Hudson Street, from Dominick to Watts Street, between the tracks of the Metropolitan Street Railway Company, and are standing up under heavy travel, if anything, better than pine adjoining them in the same location. This wood possesses the great advantage of running uniform throughout and is unlike yellow pine in that it does not have the great difference in durability between sap and heart wood. I believe it will prove a most desirable and valuable addition to the timbers available for paving-block purposes.

Returning to the question of the treatment, the advance in the price of rosin from $1.40 to $4.70 per barrel naturally suggested the use of another material, if another could be found equally good, or a reduction in the amount used, provided this reduction could be made without decreasing the quality of the product. Great difficulty has been found in obtaining any material which will take the place of rosin as a material for waterproofing and hardening the blocks. Asphalts and pitches will not mix with creosote oil, so that their use is in this way prevented, nor have they the advantage of hardening the fiber of the wood. A thorough investigation of the subject led to the conclusion that the only way in which the amount of

rosin used could be reduced would be by improving the quality of the oil. Creosote oil is generally tested for its gravity and also for its volatilizing points. By increasing the gravity of the oil and greatly reducing the amounts that evaporate at given temperatures, a far heavier, denser, and more permanent oil may be secured, and with the use of such an oil the amount of rosin may be safely cut in half. These statements are made advisedly, and are the result of long and continued experimentation, both as to the possibility of securing thorough treatment with oils of this character, and especially as to the waterproof qualities of the resulting product, and it has been found that blocks treated with oils of this character, containing only 20 to 25% of rosin, are, if anything, more waterproof than blocks treated with the lighter creosote oils with 50% of rosin.

These results lead to the very gratifying conclusion that manufacturers of wood block can produce a pavement inferior in no respect to those which have been laid in the past, and, if anything, in some respects superior, which they can safely guarantee under the heaviest travel, without being obliged to ask for block prices so high as to become prohibitive.

In speaking of these questions, I have not made any reference to the method of treating paving blocks. If this is not well known to you all, it is sufficient to say that the blocks, after being cut to size, are placed in circular cages made of band steel of approximately the diameter of the cylinders in which the treatment takes place, and are in these cages then run into the cylinders on cars. The cylinders themselves are usually about 6 ft. in diameter and somewhat over 100 ft. long, and are provided with steam coils along the bottom and sides to provide heat for drying and preparing the lumber for treatment. The blocks are heated up in this way, some works employing live steam instead of steam coils, and others a combination of the two, and after several hours, both by the use of heat and by the use of a vacuum pump, a large portion of the moisture and light volatile oils, if any, in the wood are driven off, after which the preservative material is run into the cylinder under a vacuum and hydraulic pressure of 200 lb. per sq. in. applied from 2 to 3 hr., or for such longer period of time as may be necessary to thoroughly treat the charge, this result being accomplished when the gauges show that no more material is entering the wood.

The questions above referred to do not by any means comprise all of the difficulties with which the wood block manufacturer and layer is confronted, but they are two of the most important. Among the smaller difficulties there is one that stands forth prominently in a city such as the City of New York. That is the question of repairing cuts. Under the contracts of the City of New York for street-paving work, the contractor is obliged to maintain his pavement in good condition for a period of years, this guarantee period varying in the different boroughs. If public service corporations desire to make cuts in these streets they are first required to obtain the permission of the contractor who laid the street, and this contractor is, by his contract, obliged to repair these openings at the same price at which he originally laid the street. The increase in the cost of materials and the impossibility of doing small repair jobs of this nature profitably makes this condition a very onerous one for the contractor. It would perhaps surprise many of you to learn that, upon the down-town streets which our company has laid, the area of cuts per year approximates 10% of the total area of the street. Laying aside for a time the question of the contractor's loss in making such repairs, he is also confronted with the difficulty of making them satisfactorily under any circumstances. The enormous congestion of travel on most of these down-town streets makes it impossible to do repair work on week-days; consequently these repairs are made on Sundays. The usual delay in the getting of orders, which must be obtained from the parties making the cut, together with the necessity of waiting for Sunday, and also a day upon which the weather will permit of work, generally results in the expiration of 10 days to 2 weeks before cuts are repaired, and this interval is sometimes for other causes longer. On this account the blocks which have been temporarily put back in a cut without concrete by the parties making the opening are usually almost completely destroyed by the action of travel. It is possible that this loss could be largely avoided by replacing the opening with a filling of crushed stone instead of replacing the blocks, but this the contractor would be obliged to do at his own expense, as the public service corporations would have no interest in doing it. One of the greatest difficulties with these repairs is the fact that the concrete foundations laid in cuts on Sunday are frequently not sufficiently

set by Monday morning to withstand the heavy travel which passes over them; consequently a depression results which must again be repaired, very often with the same result. Barricades placed around openings in streets such as Cortlandt street, and others of that character, would not remain in place an hour after traffic was turned into the street, unless they were guarded by a man with a shotgun, and I am not certain that they would remain in place even then. It is my opinion that many of these excavations could be avoided. The various public service corporations are notified prior to the contemplated paving of a street to put their various connections in order, and yet within 3 weeks after the beginning of work on Broadway, and before the street was by any means completed, several applications for permits to make cuts have been received, and almost invariably within a week after a street is accepted and opened in the down-town section of the city numerous applications to make cuts are received and the cuts are made. The ultimate solution of this problem is no doubt the use of pipe galleries for the use of these various corporations, but the use of such galleries on an extended scale is probably far in the future; meanwhile, the city could well afford to protect its streets laid at great cost by requiring those parties desiring to make openings to pay a considerable premium to the city for the privilege of doing so. If some such burden as this were placed upon the indiscriminate cutting of our streets, a good many of these cuts would, in my opinion, not be made, and, if made, would be made at the proper time and before the paving of the street is begun.

The question of the proper joints to use between wood paving block is one which has received a good deal of attention. Like many cases of a similar nature, it is impossible to generalize and say that any one form of joint is the best for all conditions. On streets where the travel is heavy, the blocks are laid close together and the action of travel tends to expand the head of the block slightly, resulting in the closing up of the joints, so that the surface of the street is almost as homogeneous as the surface of an asphalt street and no crevices for the entrance of water exist. No wood block pavements will be affected by the water which runs over their surface, both because this water quickly flows to the gutter, if the street is properly graded, and because the surface of the block under travel

becomes so dense and hard that they will not absorb water. Where water, however, can run under the block through the joints and remain for many days in the process of being soaked up by the pavement, expansion sometimes takes place, even with the most thorough treatment, this expansion resulting more from the character of the wood than from the character of the treatment itself. It has therefore been found that on streets of light travel where the traffic is not sufficiently heavy to cause this unification of the surface, either some form of waterproof joint should be used or else expansion joints to take up any possible expansion of the block should be provided. In the Borough of Queens last year some 50 000 sq. yd. of block were laid on streets of very moderate travel in this way. Half-inch expansion joints were left along the curb and along the rail on streets with car tracks. These joints were filled with No. 4 paving pitch. Similar joints were placed across the street at intervals of 100 ft. It is very gratifying to note that, not only has there been no evidence whatever of any swelling on these streets, but it does not appear that the expansion joint has been brought into play, as I have not been able to discover any evidence of its squeezing out, as would have been the case had the block expanded. This would seem to indicate that its use in this instance was unnecessary, but it is a precaution which I think it wise to take on streets of moderate or light travel.

In some of the western cities expansion of the pavement, especially where blocks of light treatment are used, is prevented by grouting the whole surface with a paving-pitch joint. This absolutely prevents the entrance of moisture into the surface of the pavement, but is open to a defect so serious that its use in this way is very limited. In spreading melted and hot paving pitch over the surface of a street and brushing it into the joints with squeegees, a certain amount is left on the surface, and under the action of the hot sun this becomes very sticky and disagreeable. In the nature of things, it would be used generally on residence streets, these streets having usually moderate travel. If used on these streets the results would be very unsatisfactory to the property owners, because as soon as the pitch gets sticky it is tracked into stores and houses and on to the sidewalks, to the great damage of carpets, etc. In the City of Baltimore some contracts have just

been let in which an attempt will be made to pour the joints with paving pitch, instead of spreading the pitch over the surface, but unless the blocks are separated so that the spout of the can from which the pitch is poured can be run along in the groove, my own experience is that very few, if any, workmen can accurately pour joints of this character without getting more pitch on the surface than they do into the joints.

If the pitch is spread over the surface in very hot weather and the greatest care is taken, not only to leave as little as possible on the surface when sweeping it into the joints, but also to put sand over the surface of the street while the pitch is hot, this surface pitch will be ground off by the action of travel within a reasonably short time, but even during that period the complaints from its use will be very numerous. Still another consideration arises in the case of these joints, which may not be apparent at first thought. On prominent business streets in this city, if the joints are to be made with sand, it is not practical to leave a coating of sand on the surface of the street long enough for it to work into the joints by the action of travel. This results from the fact that this sand is constantly being blown into the faces of pedestrians and into stores and office buildings, to the great dissatisfaction of the public; therefore the specifications of the City of New York, Borough of Manhattan, call for a cement joint between the blocks, instead of sand. This joint, inasmuch as it is run between the blocks in the usual manner, is very quickly applied, and the surface of the street may be swept clean of the sand top dressing within a short time. In fact, under these circumstances there seems very little necessity of using much, if any, sand top dressing at all, except for the purpose of filling up those few joints which the grout has not thoroughly filled.

In the beginning of the wood block industry in the East, blocks of uniform lengths of 8 in. were called for and have been called for during the past 5 or 6 years. The Western practice, on the contrary, has in many instances admitted blocks running in lengths from 6 to 10 or even 12 in. I am inclined to believe that this provision is a very wise one, inasmuch as the length of the block has no direct relation to its wearing qualities, and it is possible to more readily obtain a lumber supply with planks ranging, say, from 6 to 10 in. in width than by being obliged to buy all planks of the one

width. As far as the depth of the block is concerned, I believe that blocks 3½ in. in depth, of proper material and proper treatment, will be quite as serviceable as 4-in. blocks, as the rate of wear is very small, and either would probably become unserviceable after from 1 to 2 in. of the surface had worn off, and this amount of wear would not result until the lapse of a very long period of time. For decreasing the cost of the pavement on less important streets, 3-in. blocks have been very successfully used, but there are mechanical objections to using blocks of less depth than 3 in., as they have not sufficient depth to bind them properly into the street.

It has been thought by many people in the past that the constant sprinkling of wood block streets is to their advantage. My own observation is that the constant sprinkling of wood block streets is a very great disadvantage and greatly reduces their resistance to wear. The reason for this is very evident. If the surface of the street is kept constantly wet and then pounded by heavy travel, the upper fibers of the wood are softened, in just the same way that any other similar material, even stone, is more easily worn away when wet than when dry. Tests made by the United States Government, Bureau of Forestry, on the relative resistance of wood to breaking, crushing, etc., when wet and dry, show differences extending in some cases up to 100%, and the presence of moisture in the fibers of wood block will cause it to wear out much more rapidly than if it kept dry. Warren Street, New York, the first street laid in Manhattan with wood block (with the exception of Twentieth Street, originally laid some 10 years ago with Australian hard wood), was for a long period after it was laid kept continually wet under a private sprinkling contract. Last year this sprinkling was stopped. I made a careful examination of blocks taken from this street and find in many cases the tops of the blocks, instead of being pounded down and dense and hard, as is the case on streets not so sprinkled, had broomed out under the action of travel and the preservative material mechanically pounded out of the wood by the combined action of the travel and the water. This, of course, leaves the surface of the block unprotected by the antiseptic preservative and ready to decay. It also, in its spongy condition, offers poor resistance to wear. For this reason it would seem very desirable that wood block streets should be sprinkled only so much as is necessary

to sweep their surface properly and should be kept clean and free from dust, rather than to depend on the old-fashioned plan of converting the dust into mud by putting water on it. There is no difficulty in keeping wood block streets clean, because, unlike asphalt streets, the wear upon them does not produce a fine dust, and, unlike granite block streets, there are no large crevices or joints to hold dirt.

The mortar bed as a substitute for the sand cushion, used abroad extensively, and first suggested in New York City by Mr. Tillson, Chief Engineer of Highways of the Borough of Manhattan, has proved in every way a decided advance over the sand cushion. It will not hold moisture to any appreciable extent and it cannot shift, and thus always maintains the block in a rigid position. Wood block, being in itself elastic, requires no cushion, as would be the case with stone or brick, but, while wood block pavements have a very long life, if the individual blocks which compose the street are kept perfectly to grade, it is one of the most easily destroyed pavements in the world if the surface becomes uneven, and this can never be entirely prevented where a sand cushion is used.

DISCUSSION.

MR. GEORGE W. TILLSON, President of the Society.—Gentlemen, this paper is on a subject of great importance, not only to New York, but all over the country, as the question of the proper pavement has never been satisfactorily settled as yet, and it is something that has been tried in nearly every Borough of the City, so that we ought to get considerable discussion upon it. I should be glad to hear from any member of the Society.

A MEMBER.—Where they use cement grout for joints, have they found that that kept the pavement dry? In one case I think they used cement grout, but I do not know that it is waterproof.

FREDERICK A. KUMMER, ESQ., the Author.—As I attempted to say, even sand alone would be waterproof on streets where the traffic is not very heavy, as the blocks themselves are so uniform that the only streets I know of where cement grout has been made use of was where the traffic was heavy. The blocks are laid usually within $\frac{1}{8}$ in. of each other, and possibly closer; therefore, if there is an expansion of $\frac{1}{16}$ in. each way there is not any joint any longer and consequently the water cannot get in.

MR. TILLSON.—Mr. Kummer has alluded to pavements laid in Queens last year of this material. Is there no one here from Queens who has had to do with this pavement?

MR. EDWIN H. THOMES, Member of this Society.—I should like to say that we laid 3 miles of it and it has given very good satisfaction. We had some of it laid in grout, and, as nearly as I can judge, the sand is just as good as cement grout. I know in one case, along a track where we used cement grout, the blocks worked up, loose, much more than they do with sand joints. I don't know whether it was the difference in the foundation of the track or not. I should like to ask Mr. Kummer what his experience is, of blocks adjoining railroad tracks.

MR. KUMMER.—In Jamaica Avenue the track is laid practically without any ballast and the ties are very loose; the actual vertical movement on the rails is over 1 in., and with either kind of joint I do not think it is possible to hold the blocks against a track which vibrates so much. Otherwise the track construction is good. I have not seen any pavement that wore so well even along properly constructed railroad tracks.

MR. THOMES.—It was my opinion also that the foundation of the track there was very poor, and what I asked was in respect to the cement grout or sand joint along railroad tracks. I was speaking of the tracks along Cranford Avenue where cement grout was used, and in another case a sand joint, and the sand joint gave

better results than the cement grout. I was wondering what the experience was in other places.

MR. KUMMER.—I don't think the pavement is any better with cement joints than with sand joints along tracks. I don't think that makes any difference. I think if the track vibrates up and down the block goes up and the sand sets up under the block and this keeps up, over and over again, and there is one block here and another there sticking away up above the others. With a cement joint I don't think this would occur, but in every case the block would be thrown out. I think that one case is the only one where wood blocks laid up against the tracks have been of that character. Which would be the best in case of vibration in the track, I really do not know. The best thing to do would be to repair the track.

MR. WALTER G. ELIOT, Member of this Society.—I should like to ask the gentleman who just spoke, wherein lies the particular improvement in the wood block pavement, as it is used at present, over that used, for instance, in Seventh Avenue about 1875 or 1876? I recall the laying of wood pavement on creosoted boards laid on sand. I remember the laying of it distinctly. I remember the short time it took to go to pieces. The traffic on it was probably heavier that it is to-day. At the end of 4 years the wear on it had been so tremendous that it was practically impassable. It had been kept wet, but the joints were a little wider than described for the joints of the present wood block pavement; if I remember rightly, these joints are creosoted heavier, and, where possible, somewhat deeper, but I would like to know very much what constitutes, outside of the concrete foundation, the improvement in wood blocks of this time over wood blocks of that time.

MR. KUMMER.—I never saw any of the older pavements, but I believe it is generally understood that the Nicholson pavement failed because it had no foundation, and because the blocks were not treated properly; but even if the blocks had been treated properly, with no other foundation than the boards, I do not think it would wear long. I should have been very much surprised to learn that those blocks you speak of were treated. They may have been, but I don't think so. I will look into it and see if they were.

MR. ELIOT.—I should like to say that the foundation was sand, and over the sand they laid flat boards which were creosoted, so that the blocks really had a foundation; but as far as the actual treatment of the blocks is concerned it might be that I am mistaken. There was a very long stretch of it. After looking over the history of different pavements, it seems as if the later administrations have forgotten entirely the experience of the older times and this is one reason why I am anxious to hear what the difference is.

MR. KUMMER.—I have not known of any good pavements in

recent years to be laid on anything but a concrete foundation. I think otherwise they go to pieces very rapidly.

MR. THOMES.—I think it is well to state that, in the case I mentioned of the wood blocks working up along the rails, the blocks were laid on the old macadam pavement for a foundation, and this might be the reason why the block worked up. To save expense perhaps they were laid so.

MR. KUMMER.—I was under the impression that there were 2 in. of concrete on top of the macadam.

MR. THOMES.—In another case we had a foundation where the macadam was left in the center of the roadway and concrete was laid from it to the gutters. The water, of course, would go to the gutters, and near to them, where there was a concrete foundation. The foundation was all the way across, being partly of concrete and partly of macadam. In the previous case, along the rails, the macadam was washed up, which left only about 2 or 3 in. in thickness of macadam; which was considerably loosened. I think this was one of the reasons for its failure.

MR. MAX L. BLUM, Member of this Society.—I also remember having seen a considerable amount of wood block pavement in Chicago. The blocks were cylindrical in shape and of about 8 in. depth, apparently of Maine cedar. The pavement showed considerable wear and tear; in fact, were any of our New York departments to have streets in such poor condition, the entire metropolitan press would weep vitriolic tears and a special investigation would immediately be ordered.

I believe that the U. S. Wood Preserving Company has made some special investigations in Boston as to durability and rate of wear and tear of their pavement. Will Mr. Kummer please give us some of the results obtained?

MR. KUMMER.—We laid some streets there about 6 years ago and afterward relaid the blocks. The blocks we took up had been down about 4½ years and seem to have been reduced in depth about ⅛ in. We did not make any tests; we simply took the blocks out and examined them, and they seemed to be very good. We had a peculiar experience on one street. It was on a steep grade, somewhat over 3%. The blocks were very slippery, and after they had been down about 4 years they were taken up and relaid with a joint ¼ in. wide, and this joint, if I recollect rightly, was filled with Portland cement grout. The same blocks were put back again, of course. Some of the blocks were sent down to the office and measured for their reduction in depth. I think some three or four hundred of them were sent. They did not show any difference in wear on the different blocks; they seemed to wear uniformly, which was very gratifying, because otherwise they would not last very long.

MR. WISNER MARTIN, Member of this Society.—I want to express my appreciation of Mr. Kummer's paper. It has been very instructive and interesting. We have been for a number of years endeavoring to prevent, as far as possible, the opening of pavements, and our experience in this Borough has been that it is impossible to do so wholly, or nearly so. We have several conditions which are not remediable beforehand. For instance, if a man wants a water or gas service pipe to his house, we must give him a permit at once and let him have a street connection made. There are constantly new buildings being put up, which require new water, sewer, electric light and power, and telephone and telegraph connections.

It is impossible to tell about leaks. We send out a notice, as soon as we know that a street is going to be newly paved, to the companies and to the City departments directing them to put their street structures in the best possible condition of repair, and they comply with those notices—we see to it that they do—except, perhaps, the City departments; these we are not able to control. They are always willing to comply for economy's sake, but they have to have much more time than we can allow, to get appropriations. For instance, in the lower part of the Borough, there are water pipes which have been down for fully 60 years, I understand, and to be put in proper repair they should be renewed, but this cannot be done by the Water Department offhand; they must have an appropriation in advance.

There are a great many different reasons for opening the pavements, which I think I have indicated in classes, though not in detail. In the winter time, when it is difficult, if not impossible, to repair cuts, we have refused to issue permits for connections for new telephones, new gas connections, etc., holding them up for as long as 3 months sometimes, and in large numbers. I think that during the last two or three winters we have reduced to actually a minimum the openings which were made in the pavements, and yet they were in the thousands. After 11 years' experience I am convinced with Mr. Kummer that the solution is pipe galleries, which are both practical and economical, and which, we hope, are coming soon, at least in the principal streets.*

I should like to ask Mr. Kummer if in the preservative mixture now used he has been able to reduce the amount of rosin to about 25%? I read in the technical books on the preservation of woods that the United States Wood Preserving Company uses 48% of rosin.

MR. KUMMER.—We generally use whatever amount the specifications happen to call for. I don't know why it said 48%. We use

* See article by Wisner Martin in *Engineering News* of February 23d, 1906.

50% in most of the City work because the specifications call for it. We had not been able to reduce the percentage to 25. I said that I thought by using a better grade of oil with a less amount of rosin the same results could be secured.

MR. MARTIN.—But you have not done that?

MR. KUMMER.—No, not other than samples.

MR. MARTIN.—I want to say, Mr. President, that I am familiar with the experimental piece of pavement that was laid on Hudson Street, between Watts and Downing, and adjacent to the track. It is on a street which we all know has as heavy a traffic as any street in this Borough. The pavement on the outside of the rails—the inside being wood pavement—is first-class granite pavement, on concrete foundation, well laid, and that granite pavement was repaired twice on account of wear and nothing else, because it was not opened for any purpose, while the wood blocks were repaired only once. That is, the granite wore off actually, under the traffic, twice as fast as the wooden block. In this connection, Mr. Kummer, I would like to ask if these, being the black-gum blocks of which you spoke, are different blocks from those on Warren Street, or those which are being laid now.

MR. KUMMER.—There are two experimental sections laid on Hudson Street. The one you refer to is the same as those on all the other streets. The one I referred to in my paper is the section of black gum. I don't know whether your attention has been particularly called to that section. It is on Hudson Street, from Jay to Worth Street. It was put on last summer, I think in August. It is a black gum, and it has not shown any wear at all in that time since it has been there.

MR. MARTIN.—That black gum, however, has only been laid in that one place in the City as experimental?

MR. KUMMER.—Yes.

MR. ELIOT.—May I ask how long it has also been tested under the conditions of ordinary hard traffic; in our own City I mean? And also, what do you consider the life under ordinary traffic?

MR. KUMMER.—I think the first use of wood block in New York was in 1901 or 1902, if I am not mistaken. I can hardly answer, although I would like to, that question as to the life of wood paving on streets of heaviest travel, because I should think if you were to average it—would you mean a travel such as in a street, say, like many of the uptown cross streets?

MR. ELIOT.—Say Forty-second Street or Fifth Avenue.

MR. KUMMER.—I should say, judging by the experiment on Tremont Street, in Boston, which has been on about 6 years, that it would stay there about 40 years, but I should hardly want to claim that, under any condition. But under such conditions as

you mention, it should certainly last 10 years, but it would depend very much on many other conditions.

Mr. Farrell.—I should like to ask Mr. Kummer if a street repair of wood pavement can be so made that it will be equal to that of new work?

Mr. Kummer.—I think that this question applies to other pavements as well as to wood. I think that if the repair can be made and traffic excluded, it can be repaired just as well, especially where the joint is a sand joint. It would be more difficult to repair it with a cement joint, but in either case I think it can be done. I have seen cases where it was done in the Borough of Brooklyn, where it was impossible to find the cuts afterwards; but I think it is necessary that the concrete which is replaced in these cuts should have a thorough opportunity to set, otherwise it will settle down.

Mr. Thomes.—I would like to know if Mr. Kummer knows about the block pavement put down in Galveston in 1875. I have heard that it showed a wear of only ½ in. I do not know how much traffic they had over it.

Mr. Kummer.—I have seen a statement signed by the City Engineer to that effect. I have never seen the pavement, and I don't know anyone who did see it, and what the travel was I do not know. I suppose that what they call heavy travel in Galveston probably would not be very heavy travel here. I think possibly it is true. If I am not mistaken, a certain creosote company included that statement in a pamphlet which they issued, but I never saw the pavement myself. Possibly Mr. Tillson knows something about that pavement.

Mr. Tillson.—I think that the Galveston pavement was untreated block. It did unquestionably have a very long life and I think about such a life as Mr. Thomes referred to, and I know that the Galveston pavement has been referred to probably more than any other pavement laid of wood. The question of wood pavement is of great interest, as is also the history of wood pavement to me. I was quite surprised to know that, in reading up a little on this matter, wood pavement in this country has appeared in cycles of 20 years. The first wood pavement in the country was laid between 1840 and 1850 in Philadelphia, New York and Boston, at about the same time. Those old pavements were laid of ordinary wood, such as fir, hemlock and other such material, and naturally lasted but a very short time. Between 1860 and 1870 there came up the Nicholson pavement that has been referred to, and it was used quite extensively here in the East, and also in the South and to some extent in the West. Then there was an attempt to get a little better wood and also to lay in a little

better manner, although the real Nicholson pavement did not have any treating operation in the pavement; it was laid on sand and then on flags or boards about 1½ ft., and then the blocks laid on top of that. There was a great deal of it laid in Brooklyn in 1868 to 1872 and it gave about the usual satisfaction and lasted about the usual length of time that all of the Nicholson pavements did. The great trouble with wood pavement of that kind was not simply the foundation or the way the wood was laid, but, because it was untreated wood, the blocks wore unevenly; that was the great trouble, the uneven wearing of individual blocks, even if you did keep them firm and solid on a good foundation. That pavement in Brooklyn, laid as far back as 1870, when it got to be so that it could not be used any longer, in a great many cases was covered with coal tar and there was a coal-tar pavement there. After it gave out an asphalt pavement was laid on top of it, and within the last 2 or 3 years we have had an opportunity in Brooklyn of seeing considerable of that old Nicholson pavement; the subway which is being now constructed under Joralemon Street has given us an opportunity of observing it there, and Clinton Street, which we repaved with asphalt last year, had its three pavements—asphalt, coal tar and Nicholson—and we found that almost all of the plank that was on bottom of the pavement and laid on sand was in good condition, so much so that the contractors used it in the preliminary work of constructing the pavement. We also found that a great many of the blocks were just as good as they were when they were laid; others were gone entirely. That is why I say it was the unequal wearing of the blocks that made the pavements so bad. If you could get all good blocks together and all poor blocks together, you would have gotten a great deal better result. Between 1880 and 1890 there came up another wood curse for wood pavements. (I hope Mr. Kummer will excuse me for calling it a wood curse.) This was not in the East, but in the West, and there I had an opportunity to see a great deal of it, and had an opportunity to pay for some of it. That was the cedar block pavement that Mr. Blum has referred to as having seen in Chicago. Those blocks were 6 in. deep and 4 to 8 in. in diameter and were simply sawed off with guiding saws, sawing about eight blocks at a time from the cedar posts. It was first laid in Omaha in 1886. Some of it was laid on a concrete foundation and some of it on a sand foundation, but the sand was covered with hemlock boards. The blocks laid on the concrete foundation did not last any longer than the blocks laid on the plank foundation, but it was considered, when the pavement was laid, that it was to a certain extent experimental, and if we laid it on a concrete foundation these cedar blocks decayed or wore out. We would have the foundation there as a base

for another pavement and in most cases the blocks were laid on concrete. The spaces between were filled with gravel and the spaces in the gravel were filled with coal tar, requiring about 2 gal. per sq. yd. We also used at the same time cypress. The cypress was a much firmer, more compact, heavier and more dense wood, and ordinarily one would consider that it would last longer than the cedar, but as a matter of fact the cypress in most cases in 3 years was so badly decayed that it was not suitable for a pavement—that is, it was not suitable to drive over—and the cedar block in most cases in 5 or 6 years was so badly decayed that it was not a serviceable pavement, so that they were used there and in most cities but a very short time. The Chicago department used them probably more than any other city, Chicago having at one time somewhat like 1 200 or 1 400 miles; but they were not considered permanent pavements, but temporary. They were laid there, I think, in every instance on sand. Chicago, being there at the foot of the lake, where the cedar could be brought from the forests, laid its pavement cheaply, as low as 60 or 75 cents per yard, so that as a business proposition it was all right; in order to keep them in repair they were torn up a great deal. It was a business proposition to Chicago to lay the cedar blocks, even if they only lasted 3 or 4 years, and cheaper than to put down over their immense mileage of streets a pavement that would have cost more, and their interest charges would have been more than it would have been for the wood pavement, if it was actually laid.

After about 1890 or 1900 Indianapolis, as referred to by Mr. Kummer, became convinced that a treated block pavement would make a good pavement, and, while some of the streets were not entirely successful, they did continue the work until they have gotten good pavements.

Six years ago I was firmly convinced that wood would never be a suitable paving material. The developments of the last 6 years, however, have changed my mind, and I am quite firmly convinced that the present wood pavements that are being laid will be a success. The wood pavements of Europe and this country, *i. e.*, the principal pavements of Paris and London, are treated wood pavements, and the reason of that is in Paris and London the wood pavements *wear out*, but in most of our American cities wood pavements will *rot* out, if they fail, rather than wear out. I see no reasons why, if the present pavements are properly treated against decay, why they should not last, as Mr. Kummer has said, some 30 or 40 years. If they will do it, they will certainly make an ideal pavement. The only objection that has been advanced about them is this condition, and, as we have not found a perfect paving material as yet, I do not think it strange that we

find some defect in this pavement; but the Tremont Street pavement in Boston I have kept track of as much as I could, but I saw it soon after it was laid and I saw it again last winter. Unfortunately, at the time I visited it, it was raining quite heavily, so I did not care to get wet for the sake of watching the pavement there carefully, but I did watch it long enough to see that it had worn to a very slight extent; that is, squares showing any inequalities on the surface; of course, there was nothing to indicate how much of the top had been worn off. But I could see only very few places, and very small ones at that, where there were any inequalities on the surface which I thought were due to wear, and I feel that we ought to get, and I think we will get, a good result from our wood pavements. I must admit, however, that I think the Wood Preserving Company, or the Wood Contracting Company, have more faith in the pavements than I have when they lay them on lower Broadway and other heavy-traffic streets of this Borough on a 10 years' guarantee. That is something, however, that can only be ascertained by practice and experience, and I think the companies certainly have the merit of their convictions.

Some question has been raised about repairing the pavements after excavations. I think it is a safe proposition to say that no pavement can be put back in as good condition after it has been opened as it was before. There was one place, however, as referred to by Mr. Kummer, in Brooklyn where soon after the pavement was laid it was taken up for a water main, and I never (that was some 2 or 3 years ago) have since been able to see where that trench was. It was the best piece of repairing that I ever saw. You must remember, however, that, no matter how well a pavement is put back, unless the earth in the trench has been so compacted that it will not settle, when you put the pavement on it will settle, unless there is something to hold it up. The general question of street opening has given me more heartaches in the last year or two than any other one in connection with pavements. During the last 10 years we laid in Brooklyn something over 250 miles of asphalt pavements, and, rather than enjoying a drive over them, I dislike doing so on account of the number of openings that I see; as Mr. Martin has said, it is caused to a great extent by the City Departments themselves rather than by corporations, although I do not know as there is very much to be said in favor of either one of them in that respect. Of course with the real estate boom in Brooklyn, even this last year, there have been a great many plumbers' openings, over 4 000. But I do not think the time is coming when we must minimize, rather than maximize, the amount of cuts in pavements, and I have given the subject considerable thought in the last year or two, and I am firmly convinced

that we will have to come to this procedure, *i. e.*, to *order* a pavement laid one year and *lay* it the next year. That, when you have, as we had a few years ago, 300 or 400 miles of cobblestone pavement to be taken up, might seem rather a slow process, but in the condition that all of New York is getting at the present time as regards street pavements I believe that it will pay to go slowly on this question and go surely. My idea is something like this: That the Borough President should, in advance of the letting of a paving contract, notify all who are interested in subsurface construction to make any connections, repairs, etc., prior to said paving, since no permit for taking up this pavement would be granted for several years thereafter. Now that, of course, would not apply to leaks; it would not apply to new houses, possibly not vacant lots, although, to carry out the system and to have it right, the city authorities ought to have the right to compel every property owner to make connection to his own building both for sewer, water and gas, and also for electric lighting if he desires to instal same. It is done in the Western cities and it may be done here, and if they have not the authority now they can get it and not allow a single opening of any kind to be made until the inspector has visited the spot and you have his report that it is absolutely necessary to make this opening. Of course, you cannot prevent all openings, but you can, in my opinion, prevent 90% of the openings. I believe that 25% of the value of all pavements is lost by street openings. Mr. Kummer has said something about the wear of wooden blocks where they are thrown in carelessly and left in the trench until the pavement is repaired permanently. That is one of the most important things in the wear of the pavement, especially if it is a block pavement in grout, or stone, wood block or whatever it may be. A trench in a granite pavement is dry paved, as it is termed by the corporations in Brooklyn, *i. e.*, put in loose in order to allow the trench to settle before the pavement is permanently repaired. If you watch that you will see in 2 or 3 weeks that those blocks have had more actual wear than they will get in actual traffic in a year, and the reason is that the blocks, setting up irregularly as they do, the wheels give on the corners and you get a very great multiple of the wear, rather more than you would if the action of the wheels or the horses' hoofs came right on top of the block. If you can get all of the wear on top of the block, your pavement will last three or four times longer than it will if it is irregular in shape, and that is the reason why I say I think on account of our openings the loss of our pavement is fully 25%. And it is also true in asphalt,

because it does not make any difference how you repair an asphalt pavement—when the trench settles you will get a little inequality, and when you get an inequality you will get an increased wear.

MR. MARTIN.—I hardly think it is fair for Mr. Kummer to get away with his 40 years of wear for an average street. In answer to Mr. Eliot's question about wear, Mr. Eliot selected two streets for average travel which I consider very heavy streets; both Fifth Avenue and Forty-second Street have very heavy travel. But this experimental piece on Hudson Street, where I suppose without doubt the heaviest traffic in this Borough is found, and where they were put in the worst position, *i. e.*, adjoining the rails, the blocks wore 4 years, before they had to be turned over.

In regard to your remarks, Mr. President, I would like to call attention to the absolute impossibility of any of the companies foreseeing for 5 years what connections they will need for houses, or what mains they will need in the streets. For instance, I am told by the Engineer of Construction of the New York Telephone Company, Mr. Allen, that 20 years ago they could put only forty pairs of wires in a cable which was drawn in a 3-in. duct; they have been able, by improvements, to put a cable which carries 600 pairs in a 3-in. duct, and still, during the 20 years they have had to enlarge the mains, there are only four lines in the lower part of Manhattan. No man can foresee such a demand as that for telephones. Here comes the Water Department with its high-pressure water mains to go all over our downtown streets. The gas companies are selling gas in the residential districts for cooking and downtown for running engines which they never dreamt of a few years ago, so that even for mains it is impossible to keep the pavements down. I cannot see but that pipe galleries are the only solution of that question, even with all the precautions which you have mentioned.

MR. TILLSON.—I think there is no question that the gentleman's point was well taken that 5 years was simply a tentative time, but the whole proposition is in the fact that before the opening is allowed there is a thorough investigation made and it is absolutely determined by some one that it is absolutely necessary to make the opening, because there is no question in my mind that three-fourths of the openings made could be done away with through proper precaution. There are certain ones that must be made, and there we must take our chances, and there is no question, not only in the streets, but in everything else, that the great advancement that this country has taken in the last few years makes changes that no one can foresee and for which no one can plan, and for that reason it is impossible to carry out a system that we hear so much talked of in

Europe. I remember reading, a short time ago, of a street paved in England where in 15 years there had not been one block of stone taken up out of the pavement.

MR. MARTIN.—Twenty-five years.

MR. TILLSON.—I did not dare say 25, but in such a thing as that one thing is enough to determine that there has been mighty little progress or change in that city. When we see here a 4-story building torn down to make way for a 10-story, and in 3 or 4 years torn down to make way for a 20-story, we know that with all the changes in civilization that means increased mains and increased sub-surface constructions for everything and that you will find it is impossible to plan beforehand, and if Mr. Martin attempts to plan out the subways he will find he runs up against the same trouble there as he has with his others; he would not even know how large a gallery he wants any more than how large a gas main, because the history of this country has been that they do not grow as the plans grow, that they grow according to the conditions that arise afterwards.

MR. MARTIN.—Of course, this pavement was down 25 years because they had a pipe gallery in the street.

MR. TILLSON.—Then you and I are talking of different pavements.

A MEMBER.—I would like to know what would be the steepest grade in which wood pavements could be used safely?

MR. KUMMER.—I should think not over 3%, unless the blocks were separated by grooves, in which case you might go up to 5%.

MR. MARTIN.—I would like to ask Mr. Kummer if he has laid any blocks with the edges chamfered and how they wore; whether they broomed off on the edges?

MR. KUMMER.—We laid some block in Boston four years ago with the corner cut out. It did not broom off; it seemed to round off like a vitrified brick. It was on a 2 to 5% grade. It was not slippery at all. Those I spoke of in Baltimore were also grooved that way, and that was on a 5% grade. There was some complaint as to the other about the horses falling down, but it was not particularly noticeable, any more than would possibly be the case with vitrified brick, under similar circumstances. It was only slippery with a light fall of snow. I was informed that as soon as the rain got heavy and washed the dust off, it was not slippery. I would like to ask you whether tunneling under pavements is permitted in Manhattan?

MR. MARTIN.—It is against the rules.

MR. KUMMER.—I saw rather a noticeable case of it the other day.

MR. THOMES.—I would like to ask whether it would be advis-

able to use concrete in paving pits, in the joints, in a case where you have to use paving pits for inspection pits; that is, is it advisable to use concrete in the gutter?

MR. KUMMER.—I think it is, Mr. Thomes. I think it makes a very good waterproof gutter and prevents the moisture from continually centering in the lowest part of the street.

MR. THOMES.—With a sand joint it is a question in my mind whether it is advisable to specify cement grout. With the cement joints it does not seem to get into the joints and the traffic somewhat loosens it up, and it is a question in my mind whether it would pay to specify cement-grout joints. What do you think about that?

MR. KUMMER.—I think the sand joint is a great deal better and I would not specify cement grout.

MR. THOMPSON.—I have carefully refrained from taking part in the discussion, waiting for somebody else to throw stones at the gutters of these wood block pavements. My experience on one street uptown, where we paved about ½ mile with wood blocks, the surface of the roadway kept in excellent shape, *i. e.,* the center of it. It was a street with very light traffic, but we had great trouble in the gutters; in quite a number of places the blocks would rise as high as 8 or 10 in. We had to take portions of them up several times, in the gutters mainly. There was one other place where a steam boiler was located; after the blocks were taken up and put back it seemed to do away with this trouble, but I laid the trouble largely to the fact that the traffic was so light that it did not compress the ends of it sufficient to make it water-tight. The water lying in the gutter expanded the blocks, until they put them back with tight joints. Since that time they have held very nicely. The main portion of the roadway shows scarcely any wear, and I have no doubt that if there had been heavy traffic that condition would not have obtained.

MR. THOMES.—In Queens all the gutters are tar and the specifications call for expansion joints. In some cases the residue of the tar gets cold and forms lumps, where it is not smoothed down, but in general it is satisfactory.

MR. TILLSON.—We have about 2 miles in Brooklyn, all laid in sand joints and no expansion joints in the gutter, and we never had a particle of trouble in bulging at all, although I think one street, laid under private contract, did bulge up on the railroad tracks; but there was never any trouble whatever; the surface was always maintained just as it was laid.

Adjourned.

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 26.

PRESENTED SEPTEMBER 26TH, 1906.

THE HIGH-PRESSURE FIRE SERVICE IN MANHATTAN.

PRESENTED BY I. M. DE VARONA, C. E., MEMBER OF THE SOCIETY.*

WITH DISCUSSION BY
GEO. W. TILLSON, HENRY I. LURYE, WILLIAM W. BRUSH, JOS. GOODMAN, EMILIO AGRAMONTE, JR., RICHARD W. JONES, DANIEL A. CURTIN, JAMES P. REYNOLDS AND E. R. POMMER.

While holding the position of Chief Engineer of the Borough of Brooklyn, the author was directed on February 1st by the Commissioner of the Department to assume charge also as Chief Engineer of the Boroughs of Manhattan, The Bronx, Queens and Richmond, and received special directions to spare no efforts to prepare as speedily as possible plans for and complete the installation of the high-pressure fire system in the Borough of Manhattan. By the end of the first quarter, the design of all the main features of the whole high-pressure fire system had been completed and the preparation of the contracts and specifications for the various portions of the work was actively under way. The work has progressed actively since then, so that all the more important contracts for construction had been awarded by the end of the year, *i. e.*, for furnishing and installing hydrants, furnishing and laying high-pressure mains, pumps and motors, etc. A description of the plans so outlined may be of interest.

* Chief Engineer, Department of Water Supply, Gas and Electricity.

Area to be Protected.

This is shown on the attached diagram, Plate XVII, from which it will be seen that the boundary mains are laid, on the north through Twenty-third Street, on the east through Broadway to Fourteenth Street, through Fourteenth Street to Third Avenue, down Third Avenue to the Bowery, down the Bowery to Chambers Street, through Chambers Street on the south to West Street, and on the west through West Street. If we allowed a zone of 600 ft. in width beyond the limits of the mains, the protected area, therefore, would be approximately: West Twenty-fifth Street, from the North River to Fourth Avenue; Fourth Avenue to East Fifteenth Street; East Fifteenth Street to Second Avenue; Second Avenue to East Houston Street; East Houston Street to Forsyth Street; Forsyth Street to East Broadway; Catharine Street, from East Broadway to the East River; East River to Dover Street; Dover Street, Frankfort Street and Park Place, from the East River to the North River, and North River from Park Place to West Twenty-fifth Street. This district was selected, after consultation with the Fire Department, as that in which the fire losses were the greatest and which more urgently needed fire protection. The plans have been prepared so that the system may be readily extended southerly to the Battery, easterly as far as the East River, and, if necessary hereafter, northerly as far as Fifty-ninth Street, by the simple extension of the mains and probably the erection of a third pumping station. This Bureau would recommend the extension to the Battery and easterly as far as the East River as soon as the sections now under contract are completed and put into service. For convenience in handling the work and to facilitate the early advertisement of a portion of it, the system was divided into three sections, *i. e.*:

The southerly section, extending from Chambers Street to Spring Street.

The middle section, extending from Spring Street to Eleventh Street.

The northerly section, extending from Eleventh Street to Twenty-third Street.

PLATE XVII.
THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.
DE VARONA ON HIGH-PRESSURE FIRE SERVICE.

Water Required.

The general impression that an enormous quantity of water is used for fire purposes is erroneous, as shown by the following table furnished us by the Fire Department, giving the amounts used for fire purposes in the Boroughs of Manhattan and Brooklyn for the years 1900, 1901, 1902, 1903 and 1904, *i. e.:*

Water Used, Borough of Manhattan.

1900....	60 258 679	gal.,	of	which	27 955 325	gal.	were	river	water.
1901....	99 228 572	"	"	"	69 552 105	"	"	"	"
1902....	49 032 542	"	"	"	16 136 150	"	"	"	"
1903....	80 342 443	"	"	"	17 920 000	"	"	"	"
1904....	81 191 779	"	"	"	23 721 059	"	"	"	"

Average for the above 5 years, 74 010 803 gal., of which 31 056-928 gal. were river water. Daily average for the above 5 years, 117 000 gal.

Water Used, Borough of Brooklyn.

1900....	50 126 363	gal.,	of	which	22 584 630	gal.	were	river	water.
1901....	64 038 745	"	"	"	36 948 130	"	"	"	"
1902....	38 827 222	"	"	"	13 797 420	"	"	"	"
1903....	22 691 120	"	"	"	4 368 750	"	"	"	"
1904....	42 844 391	"	"	"	17 355 710	"	"	"	"

Average for the above 5 years, 43 705 568 gal., of which 19 010-928 gal. were river water. Daily average for the above 5 years, 67 000 gal.

The above figures are much higher than those found in previous memoranda furnished to a former Chief Engineer. Adopting them, however, it will be seen that the highest amount given in the above table, *i. e.,* that for 1901, is, in round numbers, 99 000 000 gal., including about 69 500 000 gal. of river water, leaving 29 500 000 gal. for fresh water. Even if this quantity be made 100 000 000 gal. per year, by comparing it with the average daily consumption of about 300 000 000 gal., it will be seen that the total amount used *during a year* for fire purposes would be only about one-third of

the amount for all purposes in *twenty-four hours,* forming, therefore, an insignificant percentage of the total consumption. The quantity needed for fire purposes may therefore be entirely neglected as a factor in determining the water supply required for the city.

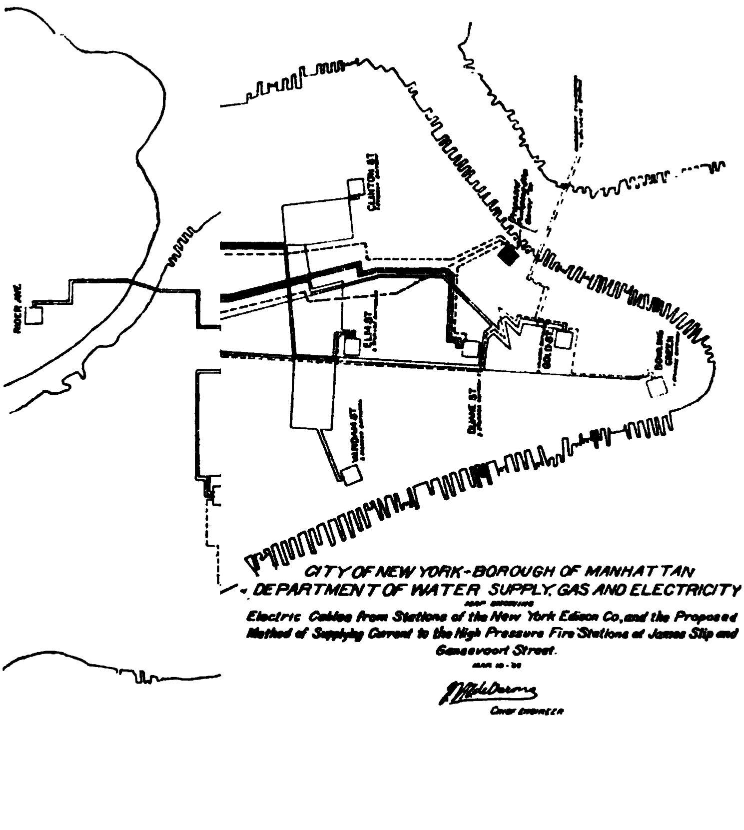
The difficulty in affording adequate fire protection has not been the lack of water, but the lack of means to concentrate the requisite amount at the scene of the fire. The amount of water in the distributing reservoirs at the dryest periods has been and is always a great many times in excess of the quantity that would be required for fire purposes for an entire year, and the adequacy of the fresh water supply for fire purposes need not, therefore, be further discussed.

The capacity of each of the proposed pumping stations supplying this system will be for the present 15 000 gal. per min., or a capacity for the combined stations of 43 000 000 gal. per day, and by the installation of the three additional units, for which provision is made in each station, this capacity can be increased to 24 000 gal. per min. at each station, or a combined capacity for both stations of, in round numbers, 69 000 000 gal. per day.

At 43 000 000 gal. per day, the capacity of the two stations would be about two-thirds of the total amount of fresh water used in Manhattan for fire purposes during the year 1903, in which, according to the figures of the Fire Department above given, the largest amount of fresh water was used by that Department, and with the capacity increased to 69 000 000 gal. the daily capacity of the stations would be larger than the total amount of fresh water used for fire purposes during the said year of 1903. When developed to 69 000 000 gal. per day, the capacity of the two stations now to be installed would be about seven-tenths of the total amount of both fresh and salt water used for fire purposes in the year 1901, when the largest amount of water of the given five years was used, the quantity having been then much greater than that of any of the other five years and exceeding the average by about 25%, *i. e.,* 250 gal. per min. A change in these premises would, obviously, make a corresponding one in the above figures without affecting, however, the general result.

With the two stations now to be built and the motors and pumps to be installed, the total capacity of these stations would

PLATE XVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DE VARONA ON HIGH-
PRESSURE FIRE SERVICE.



exceed that of all the fire engines in the Borough of Manhattan working under normal conditions and would be equivalent to approximately two-thirds of the combined capacity of all the fire engines in the Boroughs of Manhattan, The Bronx and Brooklyn working under said normal conditions. These comparisons, it must be understood, are made assuming that the engines work on one line of 2½-in. hose, say, 500 ft. long, and under a pressure of, say, 200 lb., and with the capacities printed in the official blank forms of reports of the Fire Department. It should furthermore be remembered that provision is made for the installation of still another pumping station, if required.

It is pertinent and may be of interest to compare the amount of water that may be discharged from these pumping stations with that required at the five largest fires which the City of New York has experienced since 1900. The location and duration of these fires and amount of water used in each have been officially furnished by the Fire Department for the Boroughs of Manhattan, The Bronx and Brooklyn, and are as follows:

Boroughs of Manhattan and The Bronx.

October 29th, 1900.—Tarrant fire, 276-280 Greenwich Street, of 22 hr. duration; amount of water used, 330 000 gal.

January 31st, 1901.—Wicks fire, 538-544 First Avenue, 10 hr. duration; amount of water used, 150 000 gal.

February 22d, 1902.—71st Regiment Armory, east side of Fourth Avenue, between Thirty-third and Thirty-fourth Streets, 61 hr. duration; amount of water used, 90 000 gal.

December 21st, 1903.—188-194 Mott Street, 106 hr. duration; amount of water used, 1 590 000 gal.

March 26th, 1904.—61 Broadway to 39-41 Trinity Place, 5 hr. duration; 75 000 gal. of water used.

Borough of Brooklyn.

April 9th, 1900.—Eight 1-story, twelve 2-story, two 3-story, lumber yard fire, S. S. Newtown Creek; 7 hr. duration; amount of water used, 105 000 gal.

April 30th, 1901.—558-578 Flushing Avenue, B. R. T. car sheds; 3 hr. duration; amount of water used, 45 000 gal.

May 2d, 1902.—239-245 Willoughby Street, 5-story brick, 120 ft. x 150 ft., Freeborn G. Smith Piano Manufactory, Storage; 3 hr. duration; amount of water used, 45 000 gal.

November 30th, 1903.—176-194 Montague Street, 100 x 275 ft., Academy of Music; 2 hr. duration; amount of water used, 30 000 gal.

February 19th, 1904.—Two 2-story brick and frame, 2-story brick, 4-story brick, eight 5-story brick, Messrs. F. W. Devoe & C. T. Raynolds Co., 3½ hr. duration; amount of water used, 52 500 gal.

It will be noticed that the largest fire recorded in the table is that at the premises of Nos. 188 to 194 Mott Street, the duration of which is given as 106 hr. and during which the Fire Department states that 1 500 000 gal. of water were used.* The supply from our stations during that length of time, even at the smaller capacity of 43 000 000 gal., would have been nearly 200 000 000 gal. of water.

We have reason to feel confident that the high-pressure fire system, as designed, has an adequate capacity to prevent a large conflagration by stopping the fire at its inception.

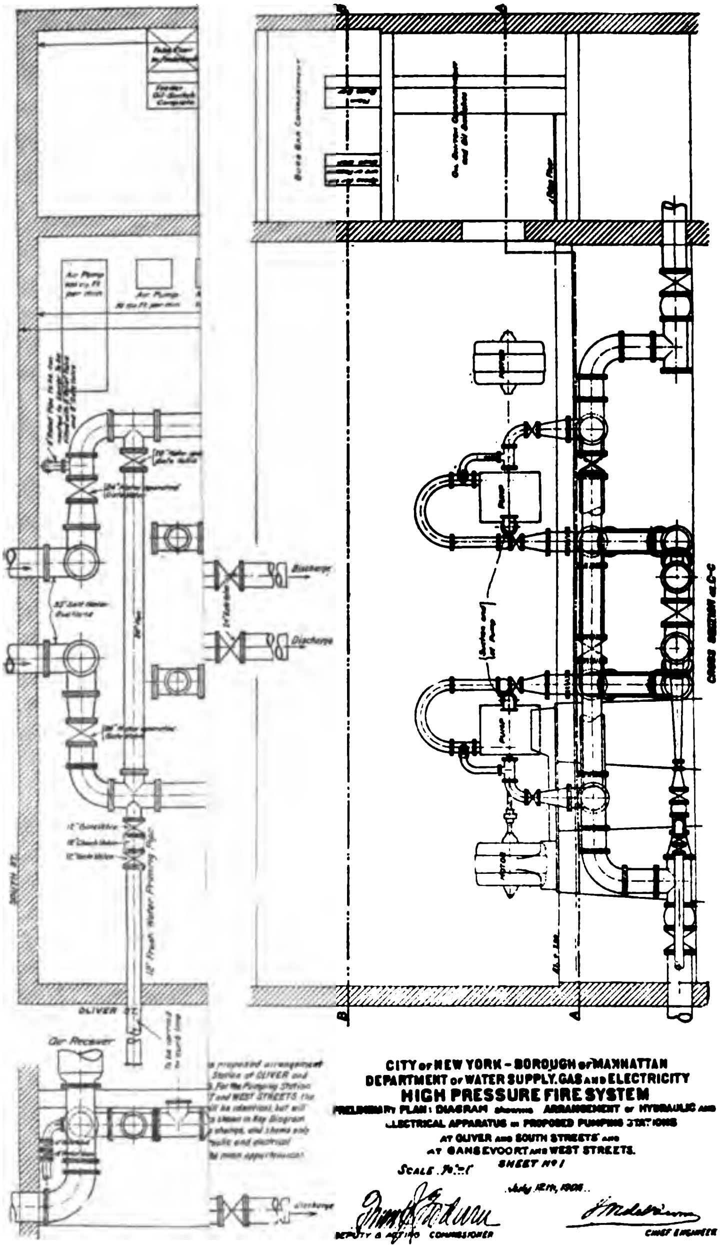
PUMPING STATIONS.

The plans provide for two stations to be built at present, with a possible third station, if the operation or extension of the system makes it advisable to increase the available supply. One station is to be located on the northeast corner of Gansevoort and West Streets and the other is to be located on the northwest corner of Oliver and South Streets. These two stations are both outside of the limits of districts in which the fire risk is at all hazardous. A conflagration could not practically affect either station, and certainly could not affect both stations. (See Plates XVII, XIX and XX.)

* N. B.—In an extract from the annual report of the Department of Water Supply, Gas and Electricity published by the *Engineering News*, these data about the operation of and amount of water used at the largest fires were included, and a correspondent pointed out the fact that in nearly all, if not in all, cases the quantities given are merely the product of the number of hours' duration of the fire by 15 000 gallons, thus leading to the assumption throughout that only one standard stream at low pressure was used on an average in the case of every fire, regardless of its character or duration. The attention of the Chief Engineer of the Department of Water Supply, Gas and Electricity was called to the matter, and as this result is certainly extraordinary he wrote to the Fire Commissioner for such explanatory statement or correction, if any, as he might deem advisable, and received in reply a communication transmitting report from the Chief of the Fire Department, in which he states that he had no corrections or other statements to make in relation to the matter, the information given being as correct as could possibly be approximated.

I. M. DE V.

PLATE XIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DE VARONA ON HIGH-
PRESSURE FIRE SERVICE.



The supply of fresh water for the Oliver Street Station would come from the following mains: 30-in. main on West Broadway, 20-in. main on Church Street, 24-in. main on Broadway, 36-in. main on Lafayette Street and Center Street, 36-in. main on Mott Street, New Bowery and Madison Street, 36-in. main on Orchard Street and 24-in. main on Essex Street. These mains would be connected to the station through a 24-in. main on Oliver Street and a 24-in. main on Chambers Street. The 36-in. main on Orchard Street and the 24-in. main on Essex Street would connect to the supply mains for the stations through the 20-in. main on East Broadway.

We will thus have two 20-in., one 24-in., one 30-in., and two 36-in. mains supplying this station, thus giving an abundant supply of fresh water.

An auxiliary salt water suction supply, which will consist of two 36-in. pipes about 140 ft. long, will bring the salt water from the East River to a suction chamber located directly in front of the pumping station. This suction will be so constructed that the pipes will always be below mean low water, thus insuring a supply at all times and avoiding the possibility of a break in the suction caused by air getting into the suction lines. On the river end of this suction there will be constructed heavy bulkhead screens, and in the suction chamber will be constructed two sets of bronze screens which will be readily accessible for cleaning. From the suction chamber there will be taken two 30-in. flanged mains to the duplicate set of suction mains in the pumping station proper. The vacuum in these 30-in. pipes will always be maintained by automatic electric vacuum pumps located on the pump room floor of the station.

At the Gansevoort Street station the fresh water supply will be derived from a 20-in. connection on Tenth Street, coming off the 48-in. main on Fifth Avenue, a 20-in. main on Seventh Avenue, a 48-in. main on Eighth Avenue, to be laid, and a 24-in. main on Ninth Avenue and Hudson Street. These mains will be cross-connected by a 36-in. main with two 24-in. mains leading from Hudson Street to the station. In addition to these mains, there is a 20-in. and 36-in. main on Fifth Avenue, which would be indirectly connected.

This station is therefore supplied from fresh water mains of ample capacity.

The salt water suction lines, as designed for this station, are practically identical with those for the Oliver Street station, except that the 36-in. lines from the North River to the station are about 650 ft. long.

The location of the stations near the northern and southern limits of the district to be protected at present has advantages in providing for a supply for the future extensions to the north and south of the area proposed.

The stations themselves are to be entirely of fire-proof construction, no wood being used in any way. The buildings are of sufficient size to give room for eight pumping units at each station, the present installation to consist of five units. The capacity of each station could therefore be increased from 15 000 gal. per min. to 24 000 gal. per min. without any change in the buildings or mains.

Motors and Pumps.

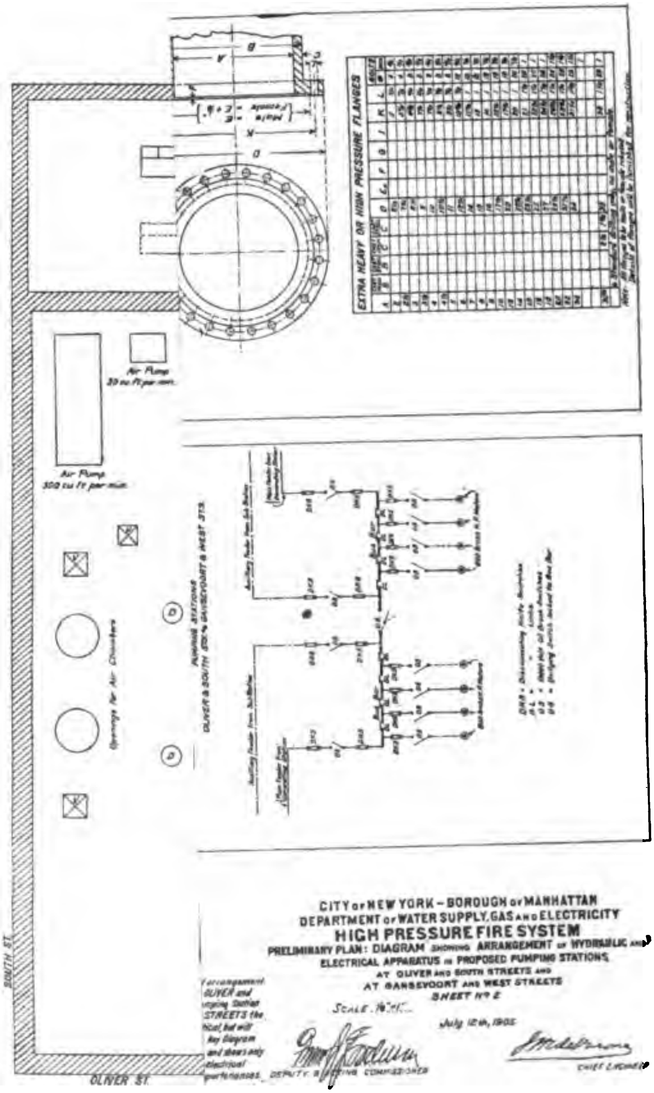
The pumping units will consist of centrifugal pumps driven by electric motors, the pump and motor being supported on one bed.

The pumps are the Allis-Chalmers 6-stage centrifugal pumps, and the motors are the Bullock 800 h.p., 6 300 volts, 68 amperes, 3 phase, 25 cycle, 4 poles, and will run at a speed of 735 revolutions per minute.

The pumps are designed with a special care as to strength and ability to resist corrosion. Each stage of the pump is designed to give a pressure of 50 lb. per sq. in., thus making the combined pressure of the 6 stages 300 lb. per sq. in., which will be the maximum working pressure of the station. These pumps are unquestionably the simplest type of machine on the market for pumping water either against a low or high head, and this simplicity was the deciding factor in the selection of this type of machinery. (See Plates XIX and XX.)

The pump being directly connected to the motor, the simple operation of a switch on the main switchboard would throw the machine into instant service and give a full pressure in about a minute's time. While a relief valve would be provided for additional precaution, the pumps nevertheless would practically take care of themselves, as they churn water when the pressure rises to

PLATE XX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DE VARONA ON HIGH-
PRESSURE FIRE SERVICE.



the maximum pressure for which they are designed and no damage would result from carelessness on the part of an employee in not properly setting the relief valve.

Venturi Meters.

Venturi meters, with automatic recording apparatus, are to be installed in the two 24-in. main discharges from the pumping stations, and a 12-in. Venturi meter with a recording apparatus is interposed between the fresh water supply and the discharge mains, with a proper check valve so as to keep the distribution system under the full Croton pressure when the pumping machinery is at rest. With these Venturi meters in service, it will be possible at all times to have an exact check on the efficiency of the stations.

Source of Electric Current.

The electric current necessary to run the stations will be furnished by the New York Edison Company, at a pressure of 6 600 volts. This company has the following steam generating and distributing stations (see Plate XVIII):

(1) 53-57 Duane Street, extending to Pearl Street, 7 600 kw. rated.

(2) 115-119 East Twelfth Street, 1 700 kw. rated.

(3) 45-47 West Twenty-sixth Street, extending to Twenty-seventh Street, 4 000 kw. rated.

(4) One Hundred Fortieth Street and Ryder Avenue, Borough of The Bronx, 4 000 kw. rated.

(5) The Waterside Station No. 1, occupying the entire block between First Avenue and East River and Thirty-eighth and Thirty-ninth Streets.

(6) The Waterside Station No. 2, occupying the entire block between First Avenue and East River and Thirty-ninth and Fortieth Streets. (This is in course of construction.)

These stations are also partially equipped with rotary converters and storage batteries, so that in case of a breakdown to the machines, the storage batteries and converters can be put into use.

The total installation of the Waterside Stations Nos. 1 and 2, are as follows:

	H. P. Boilers.	H. P. Engines.	Kw. Generators.
Total in actual use in Waterside Station No. 1...........	60 200	87 550	66 700
Being installed, Waterside Station No. 1..................	12 000	60 000	30 000
Total after complete installation	72 200	147 550	96 700
To be installed in Waterside Station No. 2...............	62 400	150 000	100 000
Total of both.................	134 600	297 550	196 700

In addition to this power, the company has feeders connecting with the Brooklyn Edison Company, so that they can be called upon for additional current, if required.

The following sub-stations are supplied by current transmitted from the Waterside stations:

(1.) No. 11 Broadway (Bowling Green).

(2.) Nos. 39-43 Gold Street.

(3.) No. 200 Lafayette Street.

(4.) Nos. 96-98 Vandam Street.

(5.) No. 152 Clinton Street.

(6.) No. 32 Horatio Street.

(7.) No. 452 West Twenty-seventh Street.

(8.) Nos. 117-119 West Thirty-ninth Street.

(9.) Nos. 118-122 West Fifty-third Street.

(10.) No. 123 East Eighty-third Street.

(11.) No. 211 East Eighty-fourth Street.

(12.) No. 128 East One Hundred and Twenty-first Street.

(13.) No. 258 West One Hundred and Twenty-fourth Street.

(14.) Nos. 44-46 West Twenty-seventh Street.

(15.) Nos. 167-169 West One Hundred and Seventh Street.

(16.) No. 100 Water Street and No. 134 Pearl Street (in course of erection).

(17.) Nos. 151-153 East Thirty-ninth Street (in course of erection).

(18.) Nos. 155-157 East Sixtieth Street (in course of erection).

All of these sub-stations are, with the exception of the Bowling Green plant, the property of the New York Edison Company, and each is equipped with rotary converters and storage batteries, and is fully equipped as a permanent center of supply.

The storage battery system at present in the sub-stations and generating stations aggregates 31 batteries installed and 4 in course of installation, having a capacity of 4 000 amperes each per hour, at 135 volts, thus giving a reserve capacity, if all generating ceased, of over 124 000 ampere-hr., at 135 volts, at present installed, and 16 000 ampere-hr., at 135 volts, in the course of installation. As the total amount of current that can be used by both stations when working under full capacity would not exceed 6 500 kw. it will be seen that there is an enormous reserve in the Edison system.

Each station will have two 250 000 C. M., 3-phase cables laid in ducts, running directly from the main generating station of the Edison Company. In addition to these feeders, there will be two independent reserve feeders running from each pumping station to sub-stations of the Edison Electric Company. Under these conditions it would certainly seem a physical impossibility for any interruption of the power supply.

CONTRACT PRICES.

Contracts were prepared and proposals were duly advertised for, and bids were opened on October 25th, 1905, for furnishing, constructing and installing five (5) electrically driven pumps, with all appliances complete, for high-pressure fire service, in a pumping station to be erected on the northwest corner of Oliver and South Streets, and the same equipment for the pumping station to be erected on the northeast corner of Gansevoort and West Streets.

On each of these contracts the Allis-Chalmers Company were the lowest bidders, the price bid for the work under each contract being $119 635.50. The contracts were each awarded to the Allis-Chalmers Company on December 18th, 1905.

The following page shows a summary of the bids received:

CANVASS OF BIDS FOR PUMPING MACHINERY, BOROUGH OF MANHATTAN, CITY OF NEW YORK.—BIDS OPENED OCTOBER 25TH, 1905.

BIDDERS' NAME AND ADDRESS.	ITEM "A," 2 500 C. Y. EXCAVATION.		ITEM "B," 350 C. Y. CONCRETE.		ITEM "C," 4 000 LIN. FT. PILING.		ITEM "D," 30 000 LB. METAL.		ITEM "E," PUMP AND ELECTRICAL EQUIPMENT.	Total.
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price	Amount.	Lump sum.	
GANSEVOORT AND WEST STREETS STATION.										
Allis-Chalmers Co., Milwaukee, Wis.	$1.00	$2 500.00	$6.75	$2 362.50	$0.30	$1 200.00	$0.03½	$1 050.00	$112 523.00	$119 635.50
Camden Iron Works, Camden, N. J.	2.00	5 000.00	9.00	3 150.00	.40	1 600.00	.03½	1 050.00	109 048.00	119 848.00
Johnson Livingston, Jr., & Co., New York City, N. Y.	2.00	5 000.00	8.00	2 800.00	.28	1 120.00	.03½	1 050.00	114 987.00	124 957.00
D'Olier, New York City, N. Y.	3.00	7 500.00	8.00	2 800.00	.35	1 400.00	.03½	1 050.00	113 746.00	126 496.00
OLIVER AND SOUTH STREETS STATION.										
Allis-Chalmers Co., Milwaukee, Wis.	$1.00	$2 500.00	$6.75	$2 362.50	$0.30	$1 200.00	$0.03½	$1 050.00	$112 523.00	$119 635.50
Camden Iron Works, Camden, N. J.	2.00	5 000.00	9.00	3 150.00	.40	1 600.00	.03½	1 050.00	109 048.00	119 848.00
Johnson Livingston, Jr., & Co., New York City, N. Y.	2.00	5 000.00	8.00	2 800.00	.28	1 120.00	.03½	1 050.00	114 987.00	124 957.00
D'Olier, New York City, N. Y.	4.00	10 000.00	8.00	2 800.00	.35	1 400.00	.03½	1 050.00	115 820.00	131 070.00

Distribution System Mains.

Plate No. XVII shows the size and location of the distribution mains adopted and is practically self-explanatory. It will be seen that the general scheme is to have two 24-in. dicharge mains leading from each station. These mains bound almost the entire area to be protected and run from one station to the other; 16-in. and 12-in. mains are run in streets parallel and intersecting these mains and they are cross-connected at frequent intervals by 20-in. mains. The 12-in. mains are only used for lateral branches and are not depended upon as arteries for carrying the supply. These mains, together with the 16-in. mains, are connected at short intervals with 20-in. mains, so that the water only has to travel a short distance through a main smaller than 20 in. before it reaches the hydrant from which it is to be drawn.

All mains are cross-connected at the points of intersection, so as to obtain the most perfect circulation possible. With this cross-connection and with the gates located at the end of every block, except for the very large mains where the gates are spaced about two blocks apart, it is possible to repair a break in any single block, without affecting any hydrants except those located on the block in question.

This system makes it practically impossible for any break in a main to appreciably affect the supply or pressure.

Careful computation of the frictional losses in the main shows that the full capacity of both stations can be delivered in any section within the area at present proposed with a pressure on the base of the hydrant of about 250 lb. per sq. in. These computations were based on the pipe formulas of Flammant for friction in cast-iron pipes and checked by Darcy's formulas, both of which are considered reliable by hydraulic engineers.

Both pumping stations can deliver their full capacity at Broadway and Spring Street with a pressure at the base of the hydrant of over 250 lb. per sq. in., assuming a pressure at the engines of 300 lb. per sq. in. The computations show that the full capacity of the Oliver Street station could be delivered at Twenty-third Street and Broadway at a pressure of not less than 250 lb. per sq. in. at the base of the hydrant.

If this system be extended to Forty-second Street, which is about the highest point of the downtown section of the city, the pressure from the Oliver Street station would be not less than 220 lb. per sq. in., and at Fifty-ninth Street would not be less than 215 lb. per sq. in. If we assume 15 lb. as a loss through the hydrant and a length of 3-in. hose of 300 ft. with a 1¼-in. smooth nozzle, the streams from hydrants at Twenty-third Street would each give about 550 gal. per min. and would rise vertically to an extreme height of 220 ft. At Forty-second Street, under the same conditions, the delivery per stream would be about 520 gal. per min. and the extreme vertical height of the stream would be about 205 ft. At Fifty-ninth Street, under the same conditions, the delivery per stream would be about 515 gal. per min., and the extreme vertical height of the stream about 200 ft.

These figures are based on the assumption that the Oliver Street station is delivering its full capacity of 15 000 gal. per min. in the vicinity of the point mentioned, and it therefore would be possible to obtain between 25 and 30 streams of a size and force equal to those given above. With the Gansevoort Street station in service, the number of streams would be doubled.

Under the proposed plan, the hydrants are always within 400 ft. of any building in the district, and there are sufficient hydrants so that if any block were on fire, 60 streams of 500 gal. per min. each, or the full capacity of both stations, could be concentrated on a block with a length of hose not exceeding from 400 to 500 ft., assuming the use of 3-in. hose and 1¼-in. nozzles. This affords adequate protection.

In the case of West Seventeenth, West Eighteenth, West Nineteenth, West Twentieth, West Twenty-first and West Twenty-second Streets, between Seventh and Eighth Avenues, no fire mains have been provided, because the character of the buildings in that neighborhood is such that a fire could readily be controlled with ordinary fire engines. The value of the existing buildings is slight, and as the old buildings are replaced by more valuable structures, 12-in. mains will be placed in these districts as shown in the same streets east of Seventh Avenue.

It may be well to note that the statement made before as to the concentration of 60 streams on any particular block must not be

applied, therefore, to the small area covered by the streets above mentioned, between Seventh and Tenth Avenues, and the general statements made in regard to the area to be protected by the high-pressure fire system are likewise inapplicable to this small area.

In case of an extension of the system to the Battery, and with the Oliver Street station out of service, the full capacity of the Gansevoort Street station could be concentrated at the Battery with a pressure at the base of the hydrant of not less than 255 lb. per sq. in. It will thus be seen that either station could break down without crippling the system, although, of course, the capacity would be reduced by one-half. It has, however, been previously shown that with the stations located as they are and the pumping plant divided into so many units, it would be practically impossible for any station to completely break down.

The layout of the mains at the station, both for suction and delivery, would be on the loop system, *i. e.*, the supply could be taken from either one of two mains and discharge from one of two mains or through both. The gates, of course, would be placed so as to control the discharge from each unit and from each main. With such a system even the breakdown of one of the discharge mains at the station would only slightly reduce the pressure at the fire and would not affect the capacity of the station, as the pumps would be capable of forcing their full capacity through the short length of a single 24-in. main that would be necessary under conditions created by such an accident.

The mains are to be of cast iron, bell and spigot pipe, with the following thicknesses:

Size of pipe.	Thickness.	Unit tensile strain with 300 lb. pressure.	Factor of safety.
24 in.	1⅞ in.	1 920	10.4
20 "	1½ "	2 000	10.0
16 "	1¼ "	1 920	10.4
12 "	1 "	1 800	11.1
*8 "	⅞ "	1 371	14.6

The special castings for the large 3-way and 4-way branches, where they are weakened by the area cut out of the branches, are to be made of steel and a very large factor of safety provided. The

* Only used for hydrant branches.

other specials are made of cast iron and are also designed with a very large factor of safety. The joints are of special form, designed to meet the requirements of the high pressure. They are deep, double lead grooves, in both spigot end and the hub end of the pipe. Tests made with the ordinary 12-in. lead joint showed that it held up to 750 lb. per sq. in., which was the highest test pressure which we could obtain at the time, and with the grooves joined it would not seem possible that any difficulty could be experienced.

The contract provided a maximum leakage allowable for each lineal foot of joint and a test pressure of 450 lb. per sq. in., this leakage being measured by pumping through a meter for a period of 10 min.

The pipe and steel castings are to be tested to a pressure of 650 lb. per sq. in. at the foundry. This, together with the test in the field, should as near as possible absolutely guarantee that the mains and appurtenances will be capable of safely withstanding the working pressure, which is about one-half of the foundry test pressure and about 70% of the field test pressure.

As under normal conditions there will be little flow, or no flow, in the mains, they are to be laid so that the outside top will be at least 5 ft. below the surface of the street or about ½ ft. below frost line. Where it is necessary to bring the main closer to the surface, special arrangement will be made to prevent freezing, and during the winter months water can be slowly pumped at frequent intervals from one station to the other, so as to change the water in the mains.

Gates.

The gates or stop-cocks are to be of cast iron, and no gate larger than 20 in. in diameter will be used in the system. All gates 12 in. and larger in diameter are fitted with by-passes, so as to relieve the pressure on the disc; and for the 24-in. mains, 20 by 24-in. reducers are to be used with the 20-in. gates. The stems of the gates are to be of nickel steel, in order to combine extreme strength with freedom from corrosion, and all their working and bearing parts are to be of bronze composition.

All of the gates, except those on the 6-in. blow-off connections, will have bell ends.

As previously stated, these gates are to be placed approximately every block, except on the very large mains, thus avoiding the cutting out of more than one block in case of any break in the mains.

Contract Prices.

It had been the purpose of the Chief Engineer of the Department of Water Supply, Gas and Electricity, to receive bids separately for the three sections. Bids, however, were opened November 22d, 1905, for the distribution system, with the three districts combined in one contract and with a time limit of 250 working days. There were only two bids received, the lower of which amounted to $3 597 965. This bid was higher than the amount allowed in the appropriation and was deemed entirely too high by the Chief Engineer of the Department of Water Supply, Gas and Electricity, who therefore advised the rejection of bids and the readvertisement, dividing the work into three contracts, as originally intended, and allowing somewhat more time for the completion of the same.

On December 22d, 1905, bids were again opened, under the revised specifications, and resulted in the receipt of

7 bids for the Southern Section,
6 bids for the Middle Section,
8 bids for the Northern Section.

The Continental Asphalt Paving Company was the lowest bider on all three sections. Their total bid for all three sections combined amounted to a total of $2 824 282.75, which was $53 922.25 under the estimated cost and $773 682.25 below the figure submitted one month earlier. The contract was awarded to the Continental Asphalt Paving Company on December 29th, 1905.

Hydrants.

Under the specifications for hydrants, the more important requirements are that the main valve shall be so designed that the pressure of water will tend to close it; that bronze shall be used for all metal parts of the valves and valve seats; that no movable iron parts shall come in contact with cast iron; that there shall be

four (4) nozzles, one 4½ in. in diameter and three 2½ in. in diameter, the sizes of these outlets being afterwards altered, as detailed further on; that all outlets shall be controlled by independent valves of composition, having rolled Tobin bronze stems; that the clear waterway through the main valve shall be not less than 28 sq. in. and the internal diameter of the standpipe not less than 9 in. in diameter; that the inlet at the base of the hydrant shall be 8 in. internal diameter and flanged; that the hydrant shall be so designed that all valves, seats, spindles, etc., can be removed without disconnecting the hydrant; that the main valve can be opened and closed by one man using a 15-in. wrench when the hydrant is under the maximum pressure of 300 lb. per sq. in.; that the fire-boat connection hydrants shall have two 3½-in. Fire Department standard female connections to fit with the fire-boat connections; that each hydrant shall be tested under 300 lb. and 600 lb. pressure, both with the main valve closed and with the main valve opened and independent valve closed; that the hydrant shall be perfectly tight under 300 lb. pressure and not show a greater leakage than ½ oz. per min., under the 600 lb. pressure.

Bids were advertised for these hydrants on February 18th, 1905, and were opened March 8th, 1905, and bids were received from five concerns manufacturing hydrants. Each of the bidders was required to submit a sample hydrant for test before the award was made, to make certain that the hydrants submitted complied with the requirements. A thorough test of the sample hydrant submitted was made before the award of the contract. These tests were briefly as follows:

1st.—Under a static pressure of 300 and 600 lb. respectively.

2d.—When pumping through a hydrant with one of the fire-boats, at pressure as near 300 lb. as possible, and opening and closing the hydrant to observe the facility of operation, freedom of water-hammer, etc.

3d.—All valves, valve seats, spindles, etc., were removed from the hydrant and the same re-assembled and then subjected to a final test under a static pressure of 300 and 600 lb.

The specifications prepared by the Chief Engineer for the Manhattan hydrants were identical with those which had been prepared by him for the Brooklyn hydrants. When the test of the latter

was made, Mr. Foster Crowell, the expert of the Merchants' Association, was invited to be present at the test and copies of the specifications were given to the New York Fire Insurance Exchange and also to the Board of Fire Underwriters. The hydrant as called for under the specifications is an improvement over that adopted by the United States Government at Washington and also over that adopted for the City of Philadelphia, this being due mainly to the experience obtained from the tests of the hydrants submitted to both these cities, so that the above statement is therefore not intended as a criticism on their hydrants or specifications for the same.

In Brooklyn, after consultation with Deputy Chief Lally and under his advice, the hydrants for that Borough were provided with three 2½-in. nozzles and one 4½-in. nozzle. Deputy Chief Lally advocated the 2½-in. nozzles, that being the usual size of hose at present in use in Brooklyn. On the recommendation of Chief Croker, however, the sizes of the nozzles have been changed so that the hydrants as finally adopted have three 3-in. nozzles and one 4½-in. steamer nozzle provided with a 3-in. outlet.

After extensive tests, the hydrant submitted by the A. P. Smith Manufacturing Company, of Newark, N. J., was selected as the one best fitted for the high-pressure fire service in the Borough of Manhattan, and a contract was entered into on November 17th, 1905, with this company for 1 050 4-nozzle post hydrants and 40 2-nozzle fire-boat connection hydrants. The time of delivery of the complete contract was to be 340 calendar days and the contract price is $104 640.

Fire-Boat Connections.

Fire-boat connections will be located on the river front at places to be selected so as to render the best service and on the end of the piers when practicable. A double female swivel increaser is provided for the use of the fire-boats in connecting their larger hose with the smaller nozzle of the hydrants on the docks.

Street Sprinkling and Flushing.

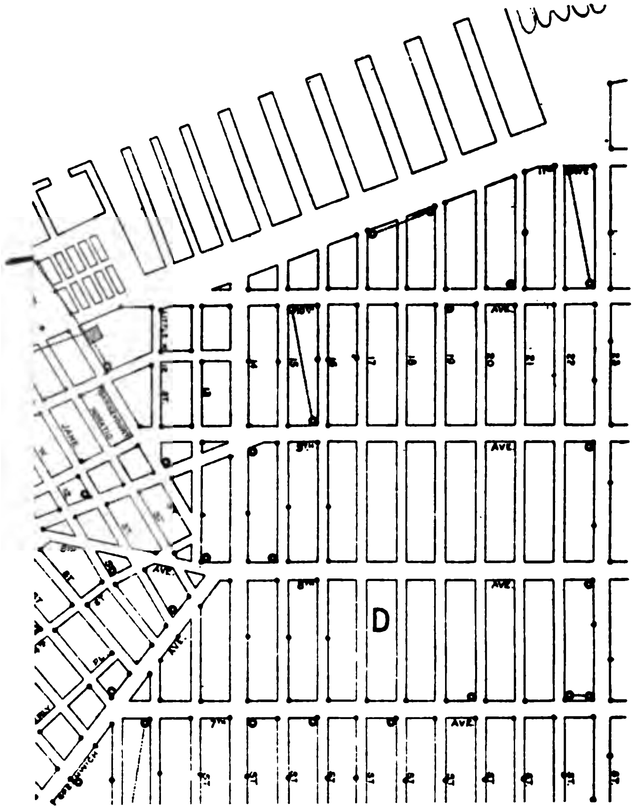
In accordance with the specific directions received, the system has been so designed that it may be used for street sprinkling and

flushing, but care has been exercised to avoid any reduction in the efficiency of the system from a fire standpoint by street cleaning appliances, should this be adopted. On each hydrant branch a 3-way branch has been set between the cap and the hydrant and to this will be connected a small cast-iron gate with a flanged pipe leading to the street cleaning hydrant. The hydrant will be so designed that the supply of water will be cut off therefrom when the pressure in the main rises above any prescribed limit, say, 70 lb. This provision is necessary to prevent injury to the men in the street cleaning gangs, when at work sprinkling or flushing, if, while doing this work, the pressure is suddenly raised without warning. The street sprinkling and flushing hydrant will be of an entirely different appearance from that of the hydrants in use, as well as from those to be installed for the high-pressure fire system, and will be plainly marked so as to offer no doubt as to the purpose for which they are intended. The high-pressure fire service hydrants are to be operated exclusively by the employees of the Fire Department.

To provide the requisite water for street sprinkling and flushing, independent pumps will be ultimately installed at the stations, as the high-pressure pumps are unsuited for this service; but as at present there are no definite data as to the amount of water required and pressure needed for street sprinkling and flushing, the installation of these special pumps will be delayed until these points are definitely settled. In the meantime the high-pressure fire service pumps would be temporarily used.

After consultation with the Commissioner of Street Cleaning in regard to location and number of hydrants, a plan was prepared by this Bureau and approved by the Street Cleaning Commissioner showing the hydrants to be installed for sprinkling and flushing purposes. As the appropriation made for the Borough of Brooklyn did not include the cost of these hydrants, and the Manhattan appropriation is not deemed sufficient to pay for their installation in this Borough, no contract has yet been made for furnishing and installing these hydrants. Sufficient work has been done on the specifications for the same so that they can be readily completed and the contract advertised as soon as the matter is definitely settled and an appropriation obtained.

PLATE XXI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DE VARONA ON HIGH-
PRESSURE FIRE SERVICE.



alarm telegraph at Headquarters, Borough of Manhattan, and also at Headquarters, Borough of Richmond, were examined and the following results were obtained:

the contract advertised as soon as the matter is definitely
·d and an appropriation obtained.

Water Curtains.

The author has not felt called upon to either recommend or condemn the installation and use of water curtains, and, at a general discussion of the high-pressure fire system with representatives of the Board of Fire Underwriters, insurance companies, Dock Department and others, he stated that in his opinion the preliminary steps should be:

1st.—To determine which buildings should be provided with water curtains.

2d.—Who should bear the expense of the installation.

3d.—What charge, if any, would be made for the water used through these water curtains.

It was further added that these points should all be settled and the necessary regulations passed, the initiative to be taken by the Fire Department and the Bureau of Buildings, the province of the Department of Water Supply, Gas and Electricity being simply to provide the necessary connections and carry into effect whatever regulations might be made in regard to the furnishing of and payment, if any, for the water supplied. The high-pressure fire system, however, has been so designed that water curtains may be readily installed, if so decided.

System of Telephone Boxes.

The system of telephone or signal boxes has been so designed that a fire in any part of a district can be watched from at least one of these telephone boxes and orders readily transmitted to the Engineer at the pumping station in regard to the requisite pressure and amount of water needed, as well as to the use of fresh or salt water, thus saving invaluable time. (See Plate XXI.) These telephone boxes have been successfully installed and operated in the Philadelphia system. Before the final completion of the plan for this city, investigations were made by Mr. G. F. Sever, Consulting Electrical Engineer of the Department, and other Assistant Engineers, accompanied by Henry E. Vineing, Electrical Engineer of the Fire Department, City of New York. The plants of the fire alarm telegraph at Headquarters, Borough of Manhattan, and also at Headquarters, Borough of Richmond, were examined and the following results were obtained:

1st.—The present fire alarm telegraph, as in the Borough of Richmond, which contained no more than 3 or 4 boxes to the circuit, was adapted for use as an auxiliary telephone service, with the simple addition of receiving and sending instruments.

2d.—In the Borough of Manhattan it was found that the conditions were entirely unfavorable to this method of auxiliary service, as the fire alarm telegraph system, located in the high-pressure fire service area, consisted approximately as follows:

Number of circuits in high-pressure area	41
Total number of pieces of signaling apparatus per circuit	1 038
Average number of pieces of signaling apparatus per circuit	25
Maximum number of pieces of signaling apparatus per circuit	46
Minimum number of pieces of signaling apparatus per circuit	7

For a telephone system which would give safe and efficient service, it is vitally necessary that the number of boxes or pieces of apparatus on any one circuit should not be in excess of 6 or 7 boxes. It is thus seen that the use of the present fire alarm telegraph in the Borough of Manhattan is entirely precluded as an auxiliary telephone system.

The contemplated telephone system consists of:

1st.—That two telephone switchboards be installed, one in each of the pumping stations.

2d.—That radiating from each of these switchboards there be provided telephone wires terminating in telephone call boxes of the type now being used by the Police Department in the Borough of Manhattan, this city, and that no more than 6 of these boxes be placed upon each line.

3d.—That connecting together the switchboards at the pumping stations there be furnished a private trunk line to be used so as to provide for the co-operation of the two pumping stations, as may be necessary.

4th.—That extending from the switchboard at each pumping station there be a special telephone line connected to the nearest telephone central office so as to provide general telephone service to be used for administrative purposes and also to be used in con-

nection with the general telephone system and the Police Department telephone system, so as to provide a breakdown connection which could be used in the event of a disaster affecting the special system connected with any office.

Two telephone switchboards should be provided, one in each of the pumping stations, as this is the obvious and natural arrangement. A dotted line dividing the districts served by the pumping stations, so far as the signaling system is concerned, is shown along Houston Street in the map attached hereto.

The two switchboards to be located at the pumping stations should be constructed with especial care so as to avoid damage by fire or otherwise. Each switchboard should be provided with a trunk line extending to the nearest telephone central office so as to provide a source of current supply for the transmitters, and in addition to this, a special breakdown machine should be installed at each pumping station, so that the chances of the switchboard being thrown out of service would be reduced to the very lowest possible degree.

Supplying current to these switchboards in this manner provides talking and signaling current to all of the telephone stations connected with the system. In this way the use of local batteries at the telephone stations is avoided and the well-known troubles incident to the use of such batteries and the danger of their freezing in winter are obviated.

Call boxes of the type now used by the Police Department are recommended because boxes of that kind were very carefully designed by the New York Telephone Company in connection with Prof. George F. Sever, Consulting Electrical Engineer of this Department. The general principles of the operation of these boxes are correct and should be adhered to, but a number of possible improvements which have been suggested as the result of experience with these boxes should be incorporated in the boxes provided for this special service.

The desirability of a trunk line joining the switchboards at the two pumping stations, to be used so as to permit co-operation between those stations, is obvious and need not be further discussed.

The desirability of having a general telephone connected with each pumping station for administrative purposes is apparent, but in addition to this, and, what is much more important, this telephone could be used in emergencies. Although every possible precaution that should be adopted is contemplated, yet, as excellent provision can be made for a breakdown by the simple expedient of a line joining the telephone central office with the pumping stations, it seems that such a plan should be adopted. In the unusual event of the special telephone system failing, the necessary instructions could be given by the Fire Department through any of the police boxes now so generally installed throughout the Borough of Manhattan. Such instructions could, by an arrangement with the Police Department, be received at the police station and then transmitted through the general telephone to the pumping stations. In addition to this, by the provision of the general telephone, any public or private telephone connecting with the city telephone system might be used in the same manner. The very great insurance which is thus obtained far outweighs the small additional expense of the two central office telephone lines.

The work comprises furnishing, installing and maintaining the following:

1.—Two telephone switchboards, one to be located at each pumping station.

2.—A total number of 213 telephone call boxes, these boxes to be located approximately as shown in Plate XVIII, attached hereto, together with circuits connecting said boxes with the high-pressure pumping stations.

3.—Two extension stations, one located in each of the pumping stations and connected with the special switchboard in its station.

4.—Suitable current supply wires extending from each switchboard to the nearest central office of the New York Telephone Company.

5.—Two reserve machines capable of supplying on emergency the necessary current for operation of the switchboards and telephone call boxes.

6.—A private tie line connecting the two switchboards.

7.—Two central office lines, one line to extend from each pumping station switchboard to the nearest central office.

8.—The right to send over each line extending from a pumping station to the nearest central office 4 000 local messages, *i. e.*, messages to other telephone stations in the Borough of Manhattan.

The company will furnish the above system and service to the City of New York, on a 5-year contract, and subject to their usual regulations, for the sum of approximately $8 000 per year; additional local messages will be charged for at their regular rates.

The company will maintain the telephone system, as installed, in good working order, but the city will furnish the operators necessary at the switchboards in the pumping stations.

The telephone boxes will be located at the most convenient points available, being attached to buildings where property owners' consents can be obtained, or otherwise being placed upon posts, in a manner similar to the fire alarm telegraph or police telephone system.

DISCUSSION.

Mr. Geo. W. Tillson.—Gentlemen, you have heard the reading of the paper. It is a subject in which we are all interested and which has given us a great deal of information. There must, however, be a great many members here from the Department of Water Supply who are not only qualified but anxious and willing to discuss this, and I would like to hear from some of them at the present time.

Mr. Lurye.—How does the Fire Department determine how much water they use for each fire?

Mr. W. W. Brush.—In Brooklyn the Fire Department practically estimates the amount by the fire streams. They turn in 250 gal. per minute for each stream and take the length of time that the streams are played on the fire. Of course, the amount that is delivered by any one of the streams depends upon the length of hose, pressure at the engines, size of nozzle, etc., but the above is the standard used in Brooklyn in determining the amounts that are played on any particular fire; but the Fire Department makes some approximate guess of the water thrown by a stream when it is running for quite a long time wetting down a fire. The figures published by the Fire Department as to the amount of water used are approximations, based upon 250 gal. per min. to the stream, and checks up reasonably well as an approximation, but it cannot be depended upon for any extreme accuracy, and for long fires the figures certainly give erroneous results.

Mr. G. W. Tillson.—This is certainly an extremely interesting phase of the subject, when we are told that the entire consumption of water for fires for the year is only one-third of the daily consumption. It is very surprising to me, and to the ordinary person, of course, it would be hardly creditable. I think Mr. Goodman is here, who had charge of the Coney Island high-pressure fire service. Nothing has been said about that and perhaps he could give us some information about it.

Mr. Jos. Goodman.—The Coney Island system differs from the Brooklyn or Manhattan systems mainly in the fact that there we have three gas engines, driving triplex double-acting pumps. The working pressure at the pumps is 150 lb. instead of 300 lb. The capacity of the station is but 4 500 gal. per minute.

Mr. G. W. Tillson.—Has that been used at any fire as yet?

Mr. Jos. Goodman.—Yes, they responded several times. As I recollect it, we use on the average $1.25 worth of gas per month for fires and about $15 per month for testing purposes.

Mr. W. W. Brush.—I don't know much about the Manhattan end of the system, but over in Brooklyn we have had some trouble

in laying mains, and those troubles are sometimes interesting because they may enable somebody else to avoid the same difficulty. With the contract requiring a test pressure of 450 lb. per sq. in. on all the mains laid, it, of course, gives a severe strain on a system, and when the question of holding the mains at bends, etc., from moving under that pressure came up, it was decided to use on large 90° bends five lengths of pipe banded together by bolts through lugs and also banded to the curve, and for 45° bends the number of pipe banded together were reduced to three lengths. It was not intended at first to use any lug pipe on the small-angle bends, but in testing a section where an offset was made by putting together two 12-in. 22½° bends the strain caused by the unbalanced pressure crushed the 12-in. pipe in the hub, and it was, of course, necessary to replace it. After that we put in lugged pipe with bolts so as to avoid any movement.

Furthermore, in testing gates, we have had a case, if I recall correctly, where five lengths of 20-in. pipe had been laid and the trench back-filled beyond the 20-in. gate on the main against which the test pressure was applied, and at the end of these five lengths there was a 20 by 20-in. 3-way, then a couple of lengths of pipe and then another 20-in. gate which was braced against the earth, and the entire mass was moved by a pressure of 450 lb. on the gate even though the backfilling had been well tamped around five lengths of pipe. It can readily be seen that care is necessary in banding and anchoring all bends, 3-ways, etc., especially in city streets, which are liable to be opened from time to time, and you may have the fire pressure on the mains while they are uncovered and you simply have to depend upon the weight of the pipe which is connected to the bends or gate in order to prevent it from moving, together with the holding power of the joints.

For the hydrant connections flange pipe is used. There has been some trouble with the flange joint, and if a lead joint had been used probably better results would have been obtained. At least there would be less difficulty in getting tight joints using the lead joint, and by bolting together the pipe from the branch over to the hydrant it would be possible to prevent any movement of the hydrant. The flanged joints have been made tight, but there has been some difficulty from sand in the trench getting into the joints and this has caused practically the only leakage which has been found. The testing of the high-pressure mains has shown that the joint used was well adapted to the high pressure the mains have to stand.

Mr. John J. Cashman, the contractor in Brooklyn, started in to lay the mains and leave them uncovered and test when uncovered, and the amount of water that disappeared or apparently disap-

peared during the test ran from, say, 30% to 100% of the leakage allowed under the specifications which amounted to 4 gal. per lin. ft. of joint per 24 hr., but in practically every case there was no evidence of water passing out from the main, which would indicate that the water pumped in took up the space filled by the air which was held in the yarn of the joints and in possibly some high points on the pipe line. This air would find its way out through openings in the joints too minute to allow water to pass through. Air cocks were placed on the mains, but there were some points where there would be a slight irregularity in grade, forming an air pocket, so therefore the actual amount of water passing out was considerably less than the test meter indicated. In several cases where all joints were exposed we had an absolutely tight line, but, nevertheless, the test showed a leakage of some 30% of the allowable leakage under the contract.

The joint having a double groove both in the hub and spigot gave additional strength to prevent the pulling apart of the mains and also gave a number of points at which the direction of flow of any leakage was changed. There was consequently only a very small fraction of 1% of the joints that it has been found necessary to touch even while under test. After several thousand feet of mains had been laid in streets where the traffic was light, the contractor commenced laying in streets where the traffic was heavy and the trenches were back-filled before the test was made. This is probably the best way to do the work, because there is no reason, with ordinarily good caulking, why the joints should not be perfectly tight. There were no special methods used in caulking other than the ordinary caulking tools and ordinary weight hammers. The men were directed by the contractor to spend all the time necessary to get good joints, but the time spent was apparently but slightly in excess of the time required to caulk a joint for low pressure.

With the gates, we have not had an opportunity yet to test the possibility of opening and closing them in case of a break, except that a test was made of a 12-in. gate at Coney Island, under 165 lb. pressure. There was no difficulty experienced by two men with a small gate wrench operating the gate easily with a by-pass closed, so there is no trouble anticipated in closing a gate in case of a break. The gates are so located that only one block will be cut out at a time in case there is any defect or break in the main, and each hydrant has a gate in front of it, as well as having independent nozzle gates.

The testing of the hydrants submitted by the manufacturers as samples was rather a difficult proposition, as the quantity of water necessary to test them for the large flows which would be expected

in actual service, together with the high pressure, was beyond the capacity of ordinary pumps. Fireboats were used by the courtesy of the Fire Department, but it was impossible to obtain more than about 225 lb. per sq. in. from the pumps on the boat. There were five hydrants submitted and tested. Four of them had pilot valves or relief valves which had a short travel. The relief valve consisted of a small central valve about 2 in. in diameter which would have a travel of perhaps ½ in., allowing the water to pass up through the small opening in the center of the main valve before the main valve left its seat. The fifth hydrant was of the balanced valve type, with only a slight difference in the area between the upper and lower valves. This hydrant did not comply with the specifications, as the pressure in the main did not tend to close the main valve and it left the other four hydrants for the test. They all, except one, failed under those tests, so the hydrant which was finally accepted was the one for which the price bid was the highest. The same make of hydrants were submitted for the Manhattan and Brooklyn contracts and the results of both tests showed only the one hydrant complying with the requirements of the specifications.

The amount of water used for fire purposes is uniformly, I think, even among engineers, estimated to be greatly in excess of what is actually required. The difficulty in fighting fires in the City of New York, both in Brooklyn and in Manhattan and The Bronx, has been the lack of an adequate fresh-water supply concentrated at the site of the fire with sufficient outlet. In Brooklyn, with the relaying of many miles of mains from 1903 to date, there has been a great reduction in fire losses. There was a reduction of about 1¼ million dollars in fire losses last year as compared with the previous year, although the number of fires increased something like 5% or 6%. This year there have been very few, if any, large fires in Brooklyn, and, as far as I know, the Fire Department have not had the efficiency of the corps reduced on account of lack of water at large fires. Of course, with the relaying of mains the efficiency of the steamers will increase greatly, as there will be an ample supply of water; but even with sufficient water supply, the ordinary fire engine is incapable of combating an extensive conflagration, and Manhattan especially is liable to such conflagration. The high-pressure fire service system was projected and is being built with a view of making it impossible for a conflagration to gain headway in the high-value districts of the city, and it is probable that as the system is proven to be efficient and results in reduced fire loses, with the consequent reduction in fire rates, it will be extended both in Brooklyn and in Manhattan.

MR. GEO. W. TILLSON.—I would like to ask Mr. Brush if they propose to use salt water in the mains in Brooklyn, or water from the regular city mains.

Mr. W. W. Brush.—Provision is made in Brooklyn for connecting one station with salt-water suctions, while in Manhattan both are connected, but it is not expected to use salt water at all in the mains. It would only be used in case of some accident occurring interfering with the entire fresh-water system, or of a large fire which required the combined efforts of the high-pressure and the ordinary "steamer" or fire-engine appliances of the borough, and that seems to be almost an impossibility when you consider that in recent years there has never been a fire where they could utilize more than a comparatively few engines on account of an inadequate distribution system. In Brooklyn it used to be considered that after the second alarm any additional alarms were practically useless, because the second alarm would usually bring out about six machines and they would require all the water that the old mains could possibly supply, and, in fact, more than they could supply, and I have seen engines working where the streams available were so small that it was simply a farce to play them on a fire. Probably twelve good streams are the most that have ever been used on any fire in Brooklyn, and those streams probably would not average over 250 or 300 gal. per min., so that when you consider that in Manhattan there is 15 000 gal. capacity for each one of the stations, and the number of streams of 300 gal. per min. each that could be utilized from those stations is 100, it seems that the amount of water and the power at which it would be delivered is greatly in excess of what could possibly be required for practical purposes. In Coney Island the only times they have used the high-pressure system it blew the buildings to pieces, and that is only 150 lb. pressure, and the firemen cannot use it at a higher pressure. It is expected for the present at least to operate the main station at 150 lb. pressure, which may be increased to 200 lb. for water towers. The trouble to be expected seems to be more in regulating the pressure and enabling the firemen to carry the hose up ladders and into the building without damage to the firemen than in supplying the amount of water and pressure.

Mr. E. Agramonte, Jr.—I only want to make one little statement in connection with the supply of water for that system. One of the principal sources of supply will be a 48-in. main now being laid under my charge from Central Park reservoir to Eighty-first Street and Eighth Avenue; thence down Eighth Avenue to Sixty-second Street; thence across Sixty-second Street to Ninth Avenue; and thence down Ninth Avenue to Gansevoort Street, where it will connect with main leading to pumping station. It is a 60-in. main from the reservoir to Eighth Avenue, at which point it reduces to 48 in., continuing as such to Twenty-ninth Street, where it reduces to 36 in. There are very few connections with existing mains, and it is intended almost entirely as a feeding main for this new system.

Mr. R. W. Jones.—In that article there was a statement that the pressure at the base of the hydrant was sufficient to give an altitude to the stream of 225 ft. Is it possible, with the ordinary 1½-in. fire nozzle such as is used, to utilize a stream like that at such a height? Will not that stream go into vapor before it will go that height? I asked that question of a gentleman who actually knows about it, because my experience is that over 125 ft. or 150 ft. the stream resolves itself merely into mist and cannot be thrown into a window of a building in which it is supposed to go, and this high-pressure system is supposed to carry it into very high buildings, 270 and 300 ft. high. I would like to ask if an available stream of water can be thrown to an elevation of 225 ft. from the nozzle of the hose.

Mr. G. W. Tillson.—I don't know which one of the gentlemen I can call upon to answer that. I know, from my experience in my younger days as a volunteer fireman, that it depends a great deal upon the size of your nozzle. If you have a 1¼-in. nozzle with a certain power you can throw a certain distance and it doesn't matter how much more power you put on, so I presume in Mr. de Varona's statement he meant that there was sufficient power to throw the water that high in the air; I don't suppose that he intended it would be an available stream for fire purposes at that height, but I would like to hear from some of the gentlemen about this.

Mr. W. W. Brush.—That is based upon the tables that Mr. Freeman prepared a good many years ago in a paper to the American Society of Civil Engineers—in 1888, I think. Of course, for high buildings there would be no attempt made to fight a fire from the street level. I am quite certain there are no figures given as to the effective height of the stream for fire-fighting purposes.

Mr. Jones.—Two hundred and twenty-five pounds at the base of a hydrant unquestionably in a water tower will throw 225 ft. or more and distribute water at 500 ft.

Mr. W. W. Brush.—The idea was simply to show the height to which the water could be sent.

Mr. D. A. Curtin.—What were the results of the tests at Coney Island? They had 150 lb. pressure there; how high did they give the stream?

Mr. Jos. Goodman.—When we were operating at 150 lb. at the pumps and delivering practically the full capacity of the station (about 4 500 gal. per min.) at one end of the system we used from 12 to 15 streams to deliver that amount. We obtained 135 lb. in the standpipe of the hydrant—about 10 lb. more than we figured on. Of course, the pressure at the nozzle varied with the length of hose used. I haven't the exact figures in my mind now, just

what that pressure was, but I believe that with three 50-ft. lengths of hose and a 1¼-in. smooth nozzle we obtained about 60 lb. at the base of the play pipe.

Mr. D. A. Curtin.—And the height of the streams?

Mr. Jos. Goodman.—We did not take such measurements, but from observation I should judge the height of the stream was fully 100 ft.

Mr. D. A. Curtin.—And 135 lb. pressure?

Mr. Jos. Goodman.—Yes.

Mr. D. A. Curtin.—Two hundred and fifty-five pounds pressure would send a stream 220 ft.

Mr. Jos. Goodman.—There is, I believe, a modification of this statement given in the paper. The statement of the height of the stream due to 225 lb. at the base of the hydrant also gives the length of hose and size and kind of nozzle, if I recollect it, and the figures were based upon the experiments of Mr. Freeman; they were not based on tests made by the Department, but the results are deduced from the experiments of Mr. Freeman. The tests in Philadelphia have borne out those results pretty well. Those figures, as Mr. Brush stated, did give the vertical height of the average extreme drops in still air and not the extreme height of the solid stream.

Mr. D. A. Curtin.—The statement is made as to the effectiveness of the joints used; and still another part of the paper speaks of the ordinary joint being tested up to 750 lb. Why use the new joint if those are facts? It increases the cost. There are grooves on the spigot and bell end of the pipe; do not the grooves on the spigot end tend to weaken the pipe?

Mr. W. W. Brush.—It was not expected that the grooves would be exactly opposite one another, although on the plans as drawn they are so shown. The two grooves were put in with the view of at least having one groove within the hub in case it was necessary to break a joint in order to go over, under or to one side of an obstruction that was met in laying the mains, and if two grooves come within the hub, of course you have the double break of the line of flow of water along the bell side or along the spigot side of the joint.

As to the question of the test on the ordinary joint, I happened to personally make the test. There were three or four 12-in. joints tested and stood the pressure of 750 lb., but there was some slight seepage at lower pressures and the leakage varied under different pressures. The new joint as designed was practically on the same principle as that of putting a shoulder around a pipe where it passed through a dam, thus breaking the line of flow of water as it was passing from the pipe to the surface. The first groove in the

bell was put in about $\frac{5}{8}$ in. so as to be within the range of caulking distance, the effect of caulking probably not extending any more than possibly $\frac{3}{4}$ in., if as much as that in a good many cases. The second ring, therefore, usually does not feel the full effect of caulking, and whether the second ring actually prevents any water from coming out I don't know, and I don't know just how I can tell. The first ring is always within caulking distance and therefore the lead is driven up hard into the ring and prevents the leakage.

As to the question of the delivery at various points, that was figured on the basis of well-known formulas for flow of water in pipes, and down at Coney Island the loss of head was less by about 5%, or the flow a little more than the figures based on the formulas would show. Of course, the mains were new and the frictional loss will increase in time. Down there the system was tested by taking almost all the water from the end hydrant and those near the end of the pipe line. The end hydrant and the one next to it were used, these being about 3 500 or 3 600 ft. away from the station, and where only three or four streams were used the pressure gauge, which was attached to a nozzle not being used and therefore simply giving the static pressure in the hydrants, showed 150 lb. when the station would be running with a pressure from 150 to 160 lb., but with twelve streams flowing and taking the full capacity of the station, some 4 500 gal. per min., the pressure on those tests dropped down then to 130 or 135 lb., as has been stated.

There was no measurement made of the height at which the stream would go. The firemen had difficulty in holding the nozzle and they had to use the stand that the hose is strapped to. The streams were usually played at an angle of about 60° to the horizon and I am sure nobody made any attempt to find out how high they went.

As far as the loss of pressure due to the 20-in. gates on the 24-in main is concerned, this construction gives you more or less of a Venturi meter, and there has never been any indication of any serious loss in this form of construction where long reducers are used. Of course, there is a very slight contraction in this case.

MR. D. A. CURTIN.—That would certainly apply to your theory, a small loss in volume of water, but in this matter it is pressure we refer to, and the more loss by friction the more loss of pressure there is going to be. You may be able to force the volume through, but not with the same pressure; energy is lost.

MR. W. W. BRUSH.—There is no more friction in a given pipe carrying a given amount of water under 1 lb. pressure than there is in the same size pipe with the same amount of water under 10 000 lb. pressure, and therefore, of course, the loss in one of those reductions, where a 20-in. gate is placed on a 24-in. main, would be

the same, assuming the same velocity in the main, whether the system was operating under 100 or 300 lb. pressure. The actual loss in any reduction of that kind as compared with the enormous losses that come in the hose that is used is so infinitesimal that it is practically unworthy of attention.

Mr. D. A. Curtin.—What was the object of using the 20-in. gates on the 24-in. main instead of using 24-in. gates?

Mr. W. W. Brush.—The object there was to avoid the multiplicity of sizes of gates and to avoid the delay in constructing a large-size gate for this pressure and the increased time of closing in case of break. It was considered that as long as 24-in. was the largest size main to be used that it would be better not to have the largest size gate, which would take longer to close, the only disadvantage being the slight loss of friction passing through that gate, which would theoretically be extremely slight and which I have found in practice, from using similar gates on other mains, would amount to but a small fraction of 1%. This loss was not considered sufficient to overbalance the advantages from having the smaller and more easily and quickly managed gate.

Mr. D. A. Curtin.—That might apply to where there was only one gate in use, but as a matter of fact, I found, in looking over the plans for the high-pressure fire system in Manhattan, that there was one gate and sometimes two gates at each street intersection. Now the loss might be slight in one gate, but it would be multiplied where you use a number of gates.

Now, then, again: How do you propose to control the water? Does the water flow from Twenty-third Street to Chambers Street and from the Bowery to West Street? Will there be a continuous flow in all of these pipes, or will you concentrate your stream to some particular point, and if so, how is that brought about quickly?

Mr. W. W. Brush.—Well, there will be no attempt to control the water where it flows; it will take its choice and will flow along the line of least resistance.

Mr. J. P. Reynolds.—I am of the opinion that the smaller gate is used on the larger mains in Boston. Maybe some of our Boston friends are here who can answer that question accurately. Although the conditions are not similar, it is good engineering practice on the new Cross River Dam, which was designed by Mr. J. Waldo Smith. In the blow-off pipes through the lower part of the dam they use that construction—the smaller valve on the large pipe—and I think Mr. Smith is a pretty good hydraulic engineer. We have adopted that construction, and I think that using this smaller gate is good engineering; it saves a good deal of construction. We are simply following out the general hydraulic engineering practice.

MR. D. A. CURTIN.—I would ask Mr. Reynolds, that being a fact, why they use a 20-in. gate on a 20-in. main and a 16-in. gate on a 16-in. main; if it is good engineering practice to reduce the size of the gates, why did they not apply it to the 20-in. and 16-in. mains? Why was not the use of 16-in. on 20-in., and 12-in. on 16-in. gates hitherto good engineering practice?

MR. W. W. BRUSH.—As to the question of the reduction of pressure in mains by using the smaller size gates: We have used them in Brooklyn for several years on our larger size distribution mains, and we have a 48-in. force main running for a distance of about 26 000 ft. where we have used 36-in. gates. We are pumping through that main daily and the friction loss, as shown by the pressure on the pump, compared with the elevation of the point of discharge, is not above what would be estimated from the volume of water that runs through the main, using the ordinary formulas and allowing for the differences which will always exist. The friction loss on that main is, I think, something like 7 lb. It is a 48-in. main, carrying 16 000 000 gal. a day.

MR. D. A. CURTIN.—How many gallons?

MR. W. W. BRUSH.—Sixteen million. The loss, as I recall it, is something under 10 lb., and, in fact, probably about 5 lb.

MR. D. A. CURTIN.—With how many gates?

MR. W. W. BRUSH.—Those gates are located about 2 500 ft. apart and the distance is 26 000 ft., bringing about ten of those gates on the line, and the main is running under a pressure normally varying from 75 to 80 lb., although at some points the pressure drops down to something like 30 lb.

MR. D. A. CURTIN.—If there is a loss of, say, 10 lb. in pressure, in a run of 25 000 ft. between gates, what would be the loss of pressure in 25 000 ft. if they had gates every 200 ft.?

MR. W. W. BRUSH.—I said the loss was in the 26 000 ft. of pipe, not between the sections. There is 26 000 ft. in which this loss occurs. In the entire line there are ten gates and the loss of pressure is somewhere from 7 to 10 lb. in the entire line.

MR. JOS. GOODMAN.—When the statement was made that the water could be delivered at Fifty-ninth Street, or at any other point, with a certain pressure, I believe it was a conservative assertion. For example, near the district under consideration a sufficient number of hydrants were selected which would deliver the total quantity of water; the friction losses in the lateral mains leading to these hydrants were computed, and then only the largest mains were considered as carrying the total delivery to the vicinity of the hydrants so selected. The decrease in frictional loss in the large mains due to the amount of water that would be carried by the large number of smaller mains (the 12-in., 16-in. and 20-in.),

would more than counterbalance, in my opinion, any losses through the smaller gates on the largest mains. Differences in elevation between points of supply and delivery were, of course, taken into consideration.

MR. JONES.—In the paper read here to-night it stated that the stems and screws of the gates were of nickel steel, and that, I think, is to prevent corrosion. Now, in describing the hydrant, except the stems and screws of the independent valve, the paper, if I remember rightly, does not state what composition the stems and screws were made of; are they of nickel steel?

MR. W. W. BRUSH.—No, the stem rod is of steel, bushed with bronze where it passes through the stuffing box, and the operating screw in the hydrant which is above the stuffing box is of bronze. It is only the independent valves which have the Tobin bronze stems. The main stem rod is of steel.

MR. JONES.—Nickel steel?

MR. W. W. BRUSH.—No, just carbon steel.

MR. JONES.—If it was thought necessary to use nickel steel in the gates for the stems and screws, why not in the hydrants?

MR. W. W. BRUSH.—I don't know.

MR. JONES.—May I ask Mr. Brush if he has had any experience in mains that have been laid with these double grooves? In those where they parted, or where they have taken them apart, has he found that the lead caulking has filled those double grooves? Has it not been his experience that the lead in the farthermost or inner groove cooled before it filled the first groove and just rounded in the second groove? What has been the trouble? The caulking did not really affect the first groove?

MR. W. W. BRUSH.—Yes, it affected it on one side; it is hard to tell whether the farther side was affected or not, but with the double groove the only thing that we have had an opportunity to see as to how well the grooves were filled was when the pipe pulled apart, where there was an unbalanced pressure under tests. I previously mentioned two or three cases where there has been a movement and the joints pulled open. In those cases the lead sheared off in the groove and even with the shearing both grooves seemed to be well filled, but I could not possibly state whether it actually was filled in such a way as to prevent the water entering the first groove or not. I doubt very much whether the groove farthest from the face of the bell would stop the passage of water under anything like the pressure it is intended to work these mains under. It would be the second groove nearest the face that would be depended upon to make the joint tight.

MR. JONES.—Even with the shearing that occurred, did it show that cross-section? Did it show a square-cut corner or a round-cut

corner in the first groove? I have had some experience that in the inner part the lead cools before it gets there and it does not take the form of the mould it was put in.

Mr. W. W. Brush.—When we cut out the lead it was with some care to see the condition of the ring on the side and it was, of course, practically impossible then to fit in the piece in the groove and see how well it fitted, but as far as the form was concerned the form was sharp, but whether it actually filled the groove or whether that sharp line was made by the pressure due to pulling I could not state.

Mr. Jones.—Mr. Brush, considering the grooves in the pipe being used for the high-pressure systems, are the half circles with sharp edges? The groove used by the New England Water-Works is an easy angle. The question arose as to the case of that sharp edge of the half circle. The groove used in the high-pressure fire service is different from any I have seen used before and I do not remember ever having seen a groove used in the spigot end of the pipe, because that would tend to weaken the weakest part of the pipe. It is well enough to groove the hub, but it will tend to weaken the spigot if you only put as much metal in it as in the body of the pipe.

Mr. E. R. Pommer.—Mr. Brush has stated how, when a few sections of their high-pressure pipe system were tested with the prescribed test pressure of 450 lb., some of the joints were crushed.

May I be permitted to inquire whether these failures may not have resulted from the fact that wherever "heavy lugs" have been put on the bell ends of the pipes, bends and branches, etc., on the Brooklyn system, these lugs have slots cast in them for anchor bolts and in every leg these slots have been sunk right down to the body of the bell instead of only to its rim.

Now, it must be apparent to anybody when looking at the usual shape of a bell, that the rim has not been put there as an ornament, but that its function must be to act as a reinforcement against the extra stress which the mouth of the bell experiences when the lead is being driven home during the caulking of the pipe joint.

Cutting the slots clear through this rim, as has been done, must therefore weaken such bells to a great extent and may possibly have caused the failures which have been mentioned by Mr. Brush. Hidden, as this defect is, by the big lugs, it easily escapes detection.

Mr. W. W. Brush.—Was that about the pipe crushing? If so, those were in 12-in. pipe and the $22\frac{1}{2}°$ bends did not have, as I recall it, any lugs on them. We did not expect to use any lugged pipe on that small angle bend. Afterwards, we banded right across

these bends from one lugged pipe to the other. There were no lugs on the casting that crushed, and the spigot end crushed and not the bell.

Mr. Lurye.—What is the practical method we are going to adopt for firemen handling the nozzle with 200 lb. or over 200 lb. pressure?

Mr. G. W. Tillson.—I don't hardly know if that is a Water Department trouble, but perhaps Mr. Brush can tell us.

Mr. W. W. Brush.—I discussed it with the Fire Department, and it is not intended to use over 200 lb. The Fire Department does not consider that it will use over 200 lb. because the present appliances are not adapted to handling any higher pressure. It is too dangerous for the men, and it is only on the assumption that American genius will be equal to the task of inventing some apparatus which will enable the firemen to control the higher pressure that it can be used except with water towers, standpipes in buildings and similar appliances. The 300-lb. pressure is provided for the future and not for the present.

Mr. J. P. Reynolds.—In regard to the regulation of these centrifugal pumps. The pumps will deliver 15 000 gal. per minute at a pressure of 300 lb., and to regulate the pressure on the discharge there will be a pressure-regulating valve which may be set by hand to any pressure which may be desired from 0 to 300. If you are going to run at 200 lb., the pump maintains 300 lb. and by-passes through this regulating valve, which gives you any desired pressure.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

Paper No. 27.

PRESENTED OCTOBER 24TH, 1906.

THE ORGANIZATION OF AN ENGINEERING FORCE IN NEW YORK CITY.

BY ALFRED D. FLINN,* C. E., M. AM. SOC. C. E., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEO. W. TILLSON, ROBERT RIDGWAY, WILLIAM D. LINTZ, HAROLD TAIT, MAX L. BLUM, FRANCIS X. A. PURCELL, AND THE AUTHOR.

The Board of Water Supply of the City of New York was appointed on the 9th of June, 1905, and the first engineering appointments took effect the 1st day of August following, so that the engineering organization is only a little over one year old. The whole force of the Board is divided into two bureaus, the Administration Bureau and the Engineering Bureau. The Administration Bureau has charge of executive and legal matters, records of Board meetings, accounts, and purchasing of supplies. The Engineering Bureau, naturally, has charge of all engineering affairs, and the executive matters directly under the charge of the Chief Engineer.

Before going further with the organization, I will show you a few slides giving some general idea of the scope of the works.

The Board was directed by Chapter 724 of the Laws of 1905, to proceed immediately and with all reasonable speed to ascertain what sources exist and are most available, desirable and best for an

* Department Engineer, Board of Water Supply.

additional supply of pure and wholesome water for the City of New York, and to make a report, accompanied by maps, plans, specifications, estimates and results of investigations.

The sources of supply in the Catskill Mountain region here shown have been pointed out for so many years and by so many eminent engineers that there is now no room for doubt that they are the most quickly available, and both the best and the cheapest large sources that can be obtained under present conditions.

Esopus Creek is to be taken at a point near Olive Bridge. Rondout Creek is to be taken at a point near Napanoch; three small streams tributary to the Rondout are to be taken as shown on the map. Schoharie Creek is to be taken at a point near Prattsville. Catskill Creek is to be taken at a point about one mile north of East Durham; six small streams tributary to aqueduct from Catskill Creek to Ashokan reservoir are to be taken as shown on the map.

The first plate is a map of both practicable and impracticable sources of supply. When the Board came into existence, legislation had ruled out the green area, from which the water flows partly into some other State, and therefore it could not be used for New York City. The large brown area is at too low an elevation to supply New York City without pumping. The red areas are also excluded by legislation relating to Dutchess and Putnam counties and the eastern part of Long Island. Hence the nearest and first available area is the Catskill water-shed, in blue. (See Plate XXII.)

A large official map was prepared to accompany the application to the State Water Supply Commission, in accordance with the provisions of Chapter 724 of the Laws of 1905, which has been published in various reports of the Board. The water-sheds of four streams in the Catskill Mountains were chosen as the sources of supply first to be developed, in the following order: that of the Esopus, the Rondout further south, the Schoharie next north, and the Catskill Creek water-shed still further north, the extremity of the latter being about 130 miles from New York City Hall.

In order to collect this water and carry it to the city, a number of reservoirs on the different water-sheds are necessary, and a main aqueduct, extending from the Ashokan reservoir to the city, with branch aqueducts bringing water from the Schoharie, the Catskill and the Rondout Creeks.

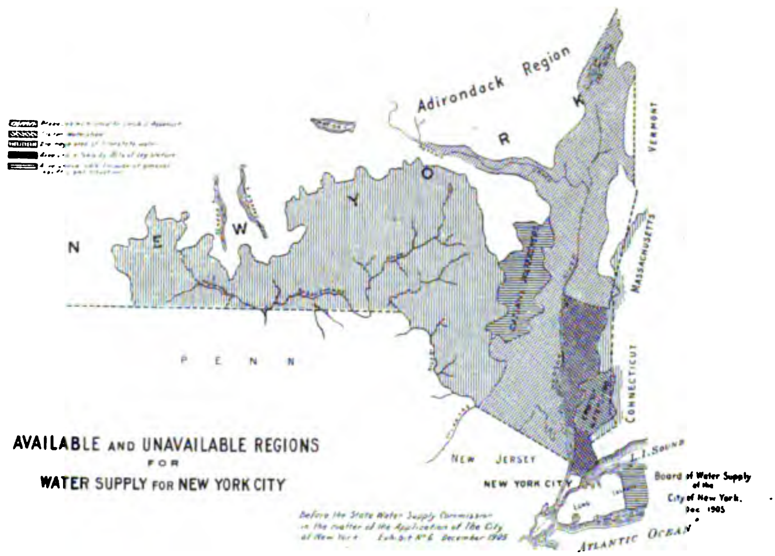

Adirondack Region
N E W Y O R K
VERMONT
MASSACHUSETTS
CONNECTICUT
P E N N
AVAILABLE AND UNAVAILABLE REGIONS
FOR
WATER SUPPLY FOR NEW YORK CITY
NEW JERSEY
NEW YORK CITY
L. I. SOUND
ATLANTIC OCEAN
Board of Water Supply
of the
City of New York.
Dec 1905

FIG. 1.

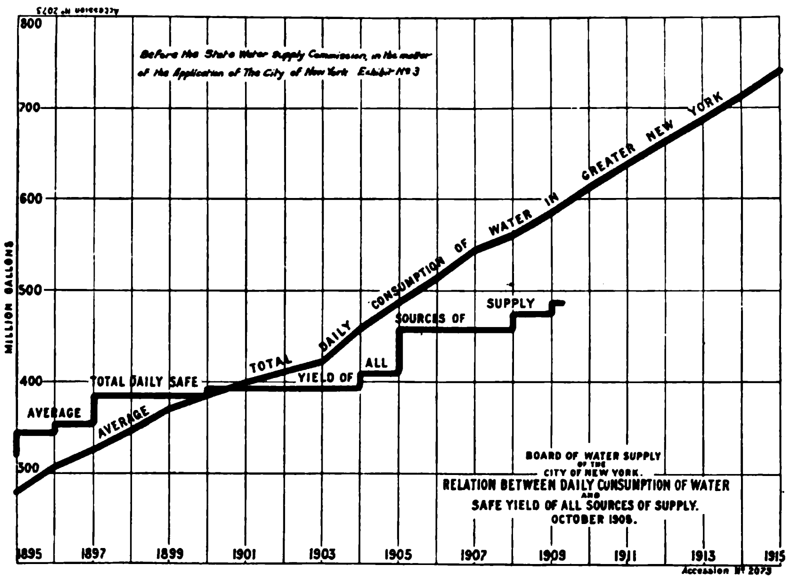

800
700
600
500
400
300
MILLION GALLONS
Before the State Water Supply Commission, in the matter of the Application of The City of New York Exhibit No 3
TOTAL DAILY CONSUMPTION OF WATER IN GREATER NEW YORK
AVERAGE
TOTAL DAILY SAFE YIELD OF ALL SOURCES OF SUPPLY
AVERAGE
BOARD OF WATER SUPPLY
OF THE
CITY OF NEW YORK.
RELATION BETWEEN DAILY CONSUMPTION OF WATER
AND
SAFE YIELD OF ALL SOURCES OF SUPPLY.
OCTOBER 1908.
1895
1897
1899
1901
1903
1905
1907
1909
1911
1913
1915
Accession No 2073

FIG. 2

A further description of these works is aside from the subject of the talk to-night and will doubtless be presented to you by other members at some other time; but let me call your attention to the engineering organization, as determined by the geography and other conditions.

At the north are the water-sheds, including the great impounding reservoirs. Extending southward is then the long line of the Catskill aqueduct, crossing the Croton water-shed. A very large storage reservoir near the city is needed, and in the vicinity of White Plains a suitable site was found, now partially occupied by the present Kensico reservoir. The aqueduct line continues to Hill View, just north of the city line, in Yonkers, whence distribution conduits will extend to the various boroughs. Near White Plains is also the site for the very extensive filter plant to be built a little later.

One of the prominent features in the work is the urgency for getting it done, and the reason for this is shown plainly in the next plate. The heavy line, made up of horizontals and verticals, shows the available yield of all the sources which up to date have been developed and put into use by the city, including the Cross River and Croton Falls reservoirs now under construction on the Croton water-shed. The verticals show the increases made in the supply from time to time. The diagonal line shows the average daily consumption and the rapid rate at which it has increased. It is all too evident that the demand has already outrun the safe yield of the sources of supply. Of course, the safe yield is figured on the basis of a series of dry years, which have tested the capacity of the water-shed. You can see that the urgency for getting more water is real. (See Plate XXII.)

Beginning with the Ashokan reservoir, one of the first great problems is to locate the dam; one of the sites which was thoroughly explored and finally abandoned was at Cathedral or Tongore Gorge, about 2¼ miles below Olive Bridge. It is a beautiful spot, but has proved more expensive as a dam site than one much nearer Olive Bridge and Bishop's Falls, not the one mentioned in the report of the Burr-Hering-Freeman Commission, but somewhat further down stream. Drilling to determine subsurface conditions was one of the lines of work which it has been necessary to provide for

in the organization. A short way above the Olive Bridge site is this natural fall, known as Bishop's Falls, shown in plate. The sites explored for the main Ashokan dam extend from Tongore Gorge to some distance above Bishop's Falls. (See Plate XXIII.)

Another line of investigation has been by means of very deep pits of considerable size, dug on suggested sites for the dam so as to fully develop the character of materials and check the indications of the borings. The materials as taken from the holes are laid out as nearly as can be in the order in which they are excavated. Another line of work for which it was necessary to provide was building a small masonry measuring-weir across Esopus Creek below the dam site, so that records could be made of the flow of the stream. Of course, it has been impossible, as yet, to build suitable offices for the field forces, because of the lack of time and because sites could not be determined until the final location of the work was settled. Consequently, various private houses and other buildings that could be leased were taken in the various towns near the scenes of surveys.

The next plate shows a bit of the aqueduct location in the Northern Aqueduct Department, of which Mr. Robert Ridgway is department engineer, and indicates some of the very steep and rough hillsides which the aqueduct line follows. (See Plate XXIII.) The aqueduct lines, as well as the dam sites, are being explored by means of wash borings and borings with diamond drills and shot drills. The next illustration shows the portable wash drilling designed by a member of the Northern Aqueduct Department. It has steam power instead of man's muscle to operate the drill. (See Plate XXIV.)

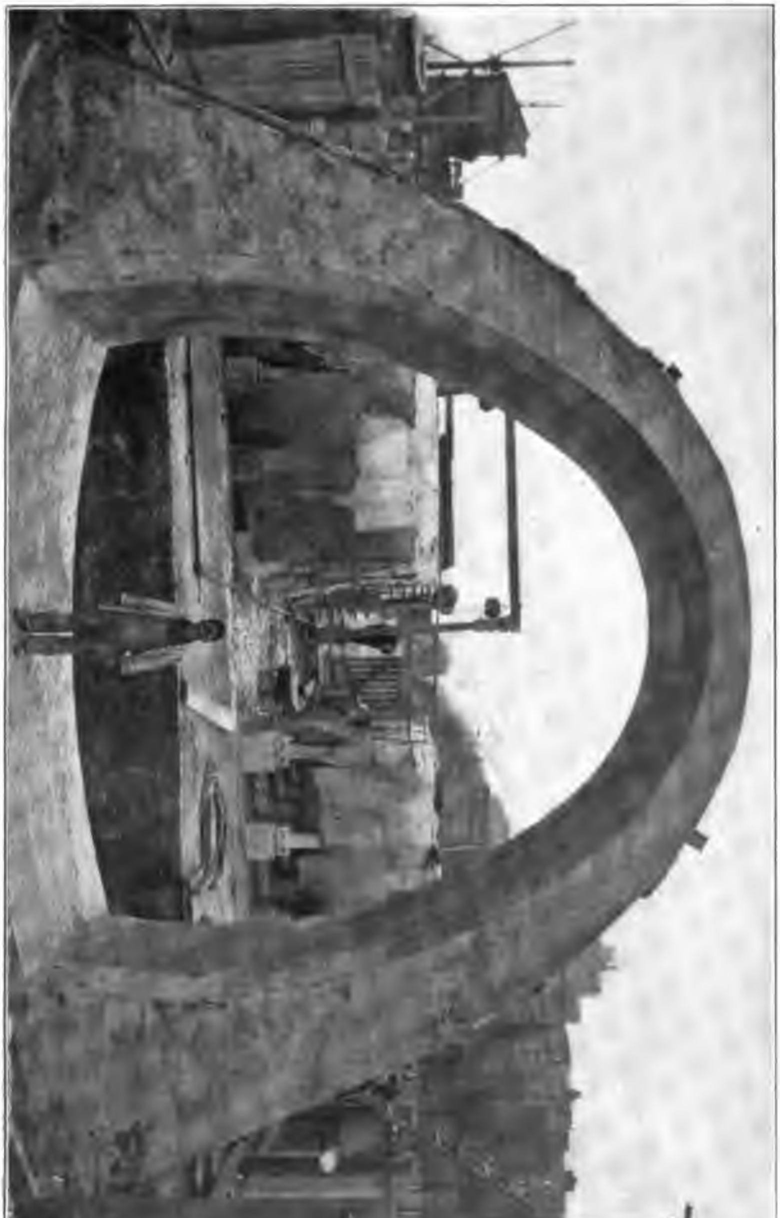
One of the prominent features in the aqueduct line is the crossing of the Hudson River. A number of lines have been explored, and the next plate shows a drilling outfit used for exploring the depth to rock in the bed of the river.

Catskill aqueduct must cross the Hudson, and the most probable place is at Storm King and Breakneck Mountains. Here the hydraulic gradient is about 400 ft. above the river surface. A deep tunnel in solid rock, probably 600 ft. or more beneath the river surface, with shafts on either shore connecting with the aqueduct, is the preferred form of crossing and promises to be the most

FIG. 1.—BISHOP'S FALL.

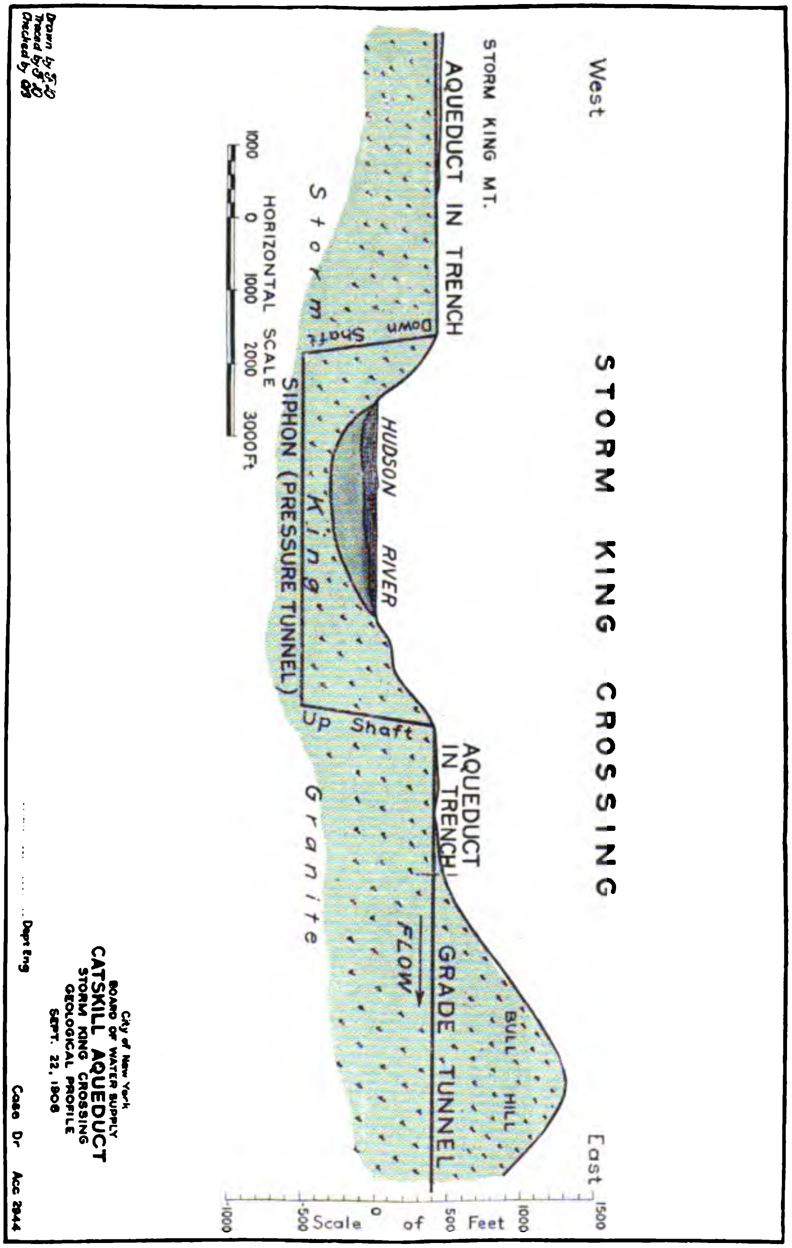
FIG. 2.—HIGH FALLS, SHOWING DIFFICULT SIDE-HILL WORK AT ATWOOD.

PLATE XXVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.



EXPERIMENTAL SECTION OF CUT AND COVER AQUEDUCT.

PLATE XXV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.

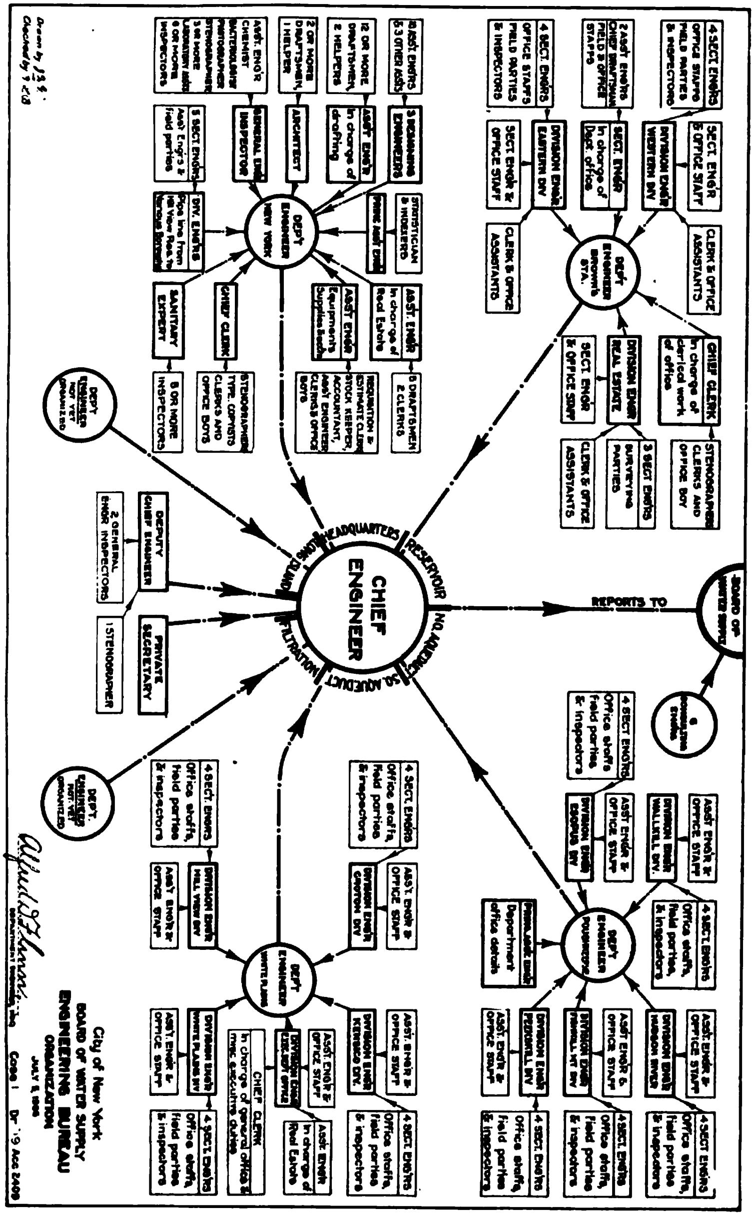


The Executive Division takes care of all the ordinary office routine. The Chief Clerk has charge of stenographic work, civil service matters, and leases of field offices. The Principal Assistant Engineer has charge of all filing and indexing, of writing of weekly and annual reports, of editing and printing of contracts and specifications, and of some special investigations. It is later intended that this division will print and send to all the offices a monthly bulletin, to keep the men informed of the progress of the work in other departments than their own and also to keep them in touch with the office in New York City, so that they may know of any actions of the Board or rulings of the Chief Engineer relating to contracts or other matters affecting the engineers. In lieu of this, at present, a weekly news letter is typewritten and sent to each department engineer, informing him of a few matters of interest.

As construction work develops, the Division of Equipment and Accounts will write the official copies of the estimates for payment under contracts. Of course, these estimates will originate in the field offices and be sent to Headquarters office for checking, copying and forwarding through the ordinary procedure, until they are paid by the Comptroller.

Referring again to the Designing Division, it may be of interest to analyze its organization, because it embraces nearly half of Headquarters force and because of the importance of its work. Some conception of the magnitude of its task may be had from the statement that, by the end of 1907, it should have gotten ready for advertising not less than $30 000 000 of contract work, besides having done much of the preliminary investigating for many millions more, while building up the force and breaking in the new men. Civil-engineering design, constituting by far the greater part, including reservoirs, dams, aqueducts, filters and the appurtenances of these principal works, is committed to three designing engineers with squads of assistants, all technically trained. The preparing of finished contract drawings and a great deal of other drafting is done by a large force of draftsmen under the direction of an assistant engineer in charge of the drafting rooms. Designing of new and remodeling of existing buildings for field offices, designing of superstructures for gatehouses, siphon chambers, pump-

PLATE XXVII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.



ing stations and other buildings, and other architectural work is in the hands of an architect, with several assistants, connected with the Designing Division. Many mechanical problems of much importance are involved in the work, and so the necessity has arisen for a mechanical engineer with a small force. With him is associated an electrical engineer. Still another special branch of designing is to be noted. In disposing of vast quantities of excavated materials, building embankments for aqueducts and dams, and treating the margins of reservoirs, opportunities are presented for creating pleasing effects at trifling cost which will be a joy to the public for generations. A skillful landscape engineer will, therefore, be added to the force later, so that under his guidance these desirable results may be accomplished and the works rescued from becoming a series of awkward embankments, ragged dirt piles, ill-considered wood-cuttings, and scars in the scenery.

Besides the office duties just described, the studies, surveys, and construction required for distributing the Catskill Mountain water from the Hill View terminal reservoir to the various boroughs has been assigned to Headquarters Department.

Turning to the field departments, it is logical to begin at the sources of supply. In the Reservoir Department the basis of organization was partly the nature of the work and partly location. One division was created to have charge of the surveys for real estate purposes, with an office in Kingston, and field parties traveling over the whole area of the reservoir. Two other divisions have been created, known as the Western and Eastern, dividing the reservoir into two parts, for topographical surveys, and studies relating to highways, railroads, and other questions. As the work progresses, the allotments to the different divisions may be changed from time to time to adapt the organization to changing conditions due to construction and the extension of operations to other watersheds than that of the Esopus, where practically all the work of this department is now located. Other divisions may be added.

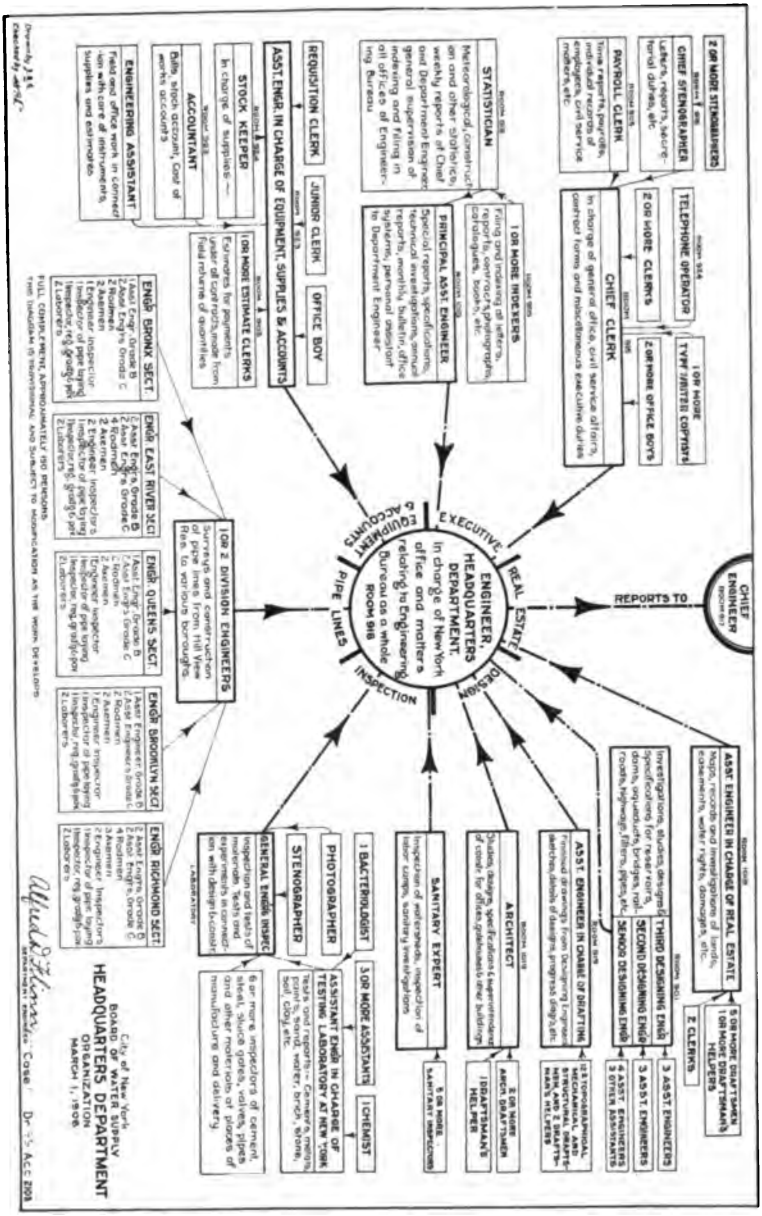
The Catskill aqueduct being a long line of works, somewhat resembling a railroad, it was most natural to divide it into lengths. Beginning with the smallest unit, the sections average, say, 3 miles; these sections are grouped together into divisions, and several divisions constitute a department. There are two of these

departments, the Northern Aqueduct Department, and the Southern. Geographical names are given to the divisions, and the sections are numbered. This scheme of organization is plainly shown by the diagrams. There will be usually four sections in each division. The section engineer will be a man of sufficient ability and experience to have immediate charge of construction work in the field, when construction begins, and at present is in responsible charge of surveys. He should be a man who can see that line and grade are given properly; who can answer the numerous small questions in connection with contract work; who can see that the inspectors are doing their duties faithfully, and that the necessary data for records and estimates are duly collected and forwarded. Section engineers report to the division engineer, who has general supervision over them and handles the larger questions in connection with the contracts, and in turn reports to the department engineer.

This department covers about 58 miles of the Catskill aqueduct, which will have not less than 500 000 000 gal. daily capacity. This is nearly twice the length of the new Croton aqueduct, and the capacity of the new Croton is only 300 000 000 gal. So it will be recognized that the engineer of this department, in comparison, has nearly twice as much work under his charge, as to length of line, and for cost perhaps three times as much, as had the Chief Engineer of the new Croton aqueduct. In passing, it may be stated that the estimated total cost of the portions of the works in the Reservoir Department, and the Northern and Southern Aqueduct Departments is, approximating roughly, $35 000 000 in each department. Each division engineer has about 12 miles of aqueduct, or corresponding responsibility. For a comparison, I might remind you that the new aqueducts recently constructed for the Boston Metropolitan Districts, the Wachusett and the Weston, are each approximately 13 miles long and of 300 000 000 gal. daily capacity. The section engineer, with 3 or 4 miles of aqueduct under his charge, will have something like $1 500 000 to $2 000 000 worth of work. Works of even this cost in many places would be considered a worthy responsibility for a chief engineer.

The organization is intended to carry the responsibility up, step by step, to the department engineers, who advise on all the

PLATE XXVIII.
THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION OF AN ENGINEERING FORCE.



larger questions with, and report directly to, the Chief Engineer. It is evident from the map and from the diagrams so far presented, that the department engineer in each of these three departments must bear considerable responsibility, with much self-dependence, as he is too far from Headquarters to ask the chief in each emergency what to do.

The Southern Aqueduct Department, while covering a shorter length of aqueduct line, has under its charge the very large Kensico storage reservoir, with a capacity of 40 000 000 000 gal. (30 000-000 000 gal. is the total for the new Croton reservoir, the available capacity of which is 24 000 000 000 gal.), and the Hill View terminal distributing reservoir, with an ultimate total capacity of 2 000-000 000 gal. Each of these reservoirs in itself would be a good sized job for a department in many large organizations. The arrangement of this department is much the same as the Northern Aqueduct Department, being divided into sections, the sections grouped into divisions, and the divisions reporting to the department office. The department office for the Northern Aqueduct Department is located at Poughkeepsie, although this town is not on the aqueduct line, because it is more accessible from New York City and from the various parts of the department, part of which is on the east and part on the west side of the Hudson River. The Southern Aqueduct Department office is at White Plains, because this place is near to the Kensico Reservoir work and also centrally located, with good means of transportation to different parts of the department and to New York City. Mr. Merritt H. Smith is the department engineer of the Southern Aqueduct Department. The organization as originally projected has been built up substantially on the lines shown, and up to the present hour seems to be working quite satisfactorily.

A year ago the first of August there were only two members in the engineering force, and the offices contained nothing but a little dust on the floors. In the middle of this past summer a maximum of about 550 employees had been collected. Although some were temporary appointees, a large majority are still actively at work in the Engineering Bureau. This force has been fully equipped with field instruments, office supplies and stationery. Twenty-two buildings have been rented and made available as temporary offices

at convenient points along the line. Besides, very early in the work, the approximate estimate of the cost of the whole work, the large official map and the other necessary preliminaries for application to the State Water Supply Commission were prepared inside of a very few weeks by a force hastily brought together.

When the Commissioners were appointed, they early took steps to secure certain exemptions from the Civil Service Commission. Some of these exemptions did not fit very well the requirements of the work, but were made useful so far as they could be at the time, and steps were at once taken to secure exemptions for the department engineers and other needed officers. To organize a force of several hundred engineers naturally would cause a drain upon existing civil service lists, and such existing lists were inadequate for the demands made upon them. Therefore, steps were early taken for special examinations. Most of the men on the regular city lists refused service so far from town as would be necessary on this work, stretching, as it does, 130 miles to the north of the city, and in the Long Island department 80 miles to the east of the city. Therefore, special examinations have been held from time to time establishing lists of axemen, rodmen, and different grades of assistant engineers. In order to start before special lists could be made available, existing city lists were called upon and some of the men who offered themselves from other city departments were taken by transfer. The only way to start this force was by transfer and such few appointments as could be made from the lists existing. In this way, one at a time, a small force of draftsmen were first gotten together and then small field forces. Between the 1st of August and the 9th of October, the field forces reconnoitered and made some detailed surveys of the whole length of the Catskill aqueduct line and some of the reservoir sites, and got their notes in such condition that the official map could be prepared, partially by the use of those notes and partially by the use of existing maps. The force early showed the mettle of which it is made by the willingness with which the men worked from early dawn until past midnight in getting this work done in record time at less than half the cost appropriated for it. That spirit has been maintained up to the present time.

PLATE XXIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.

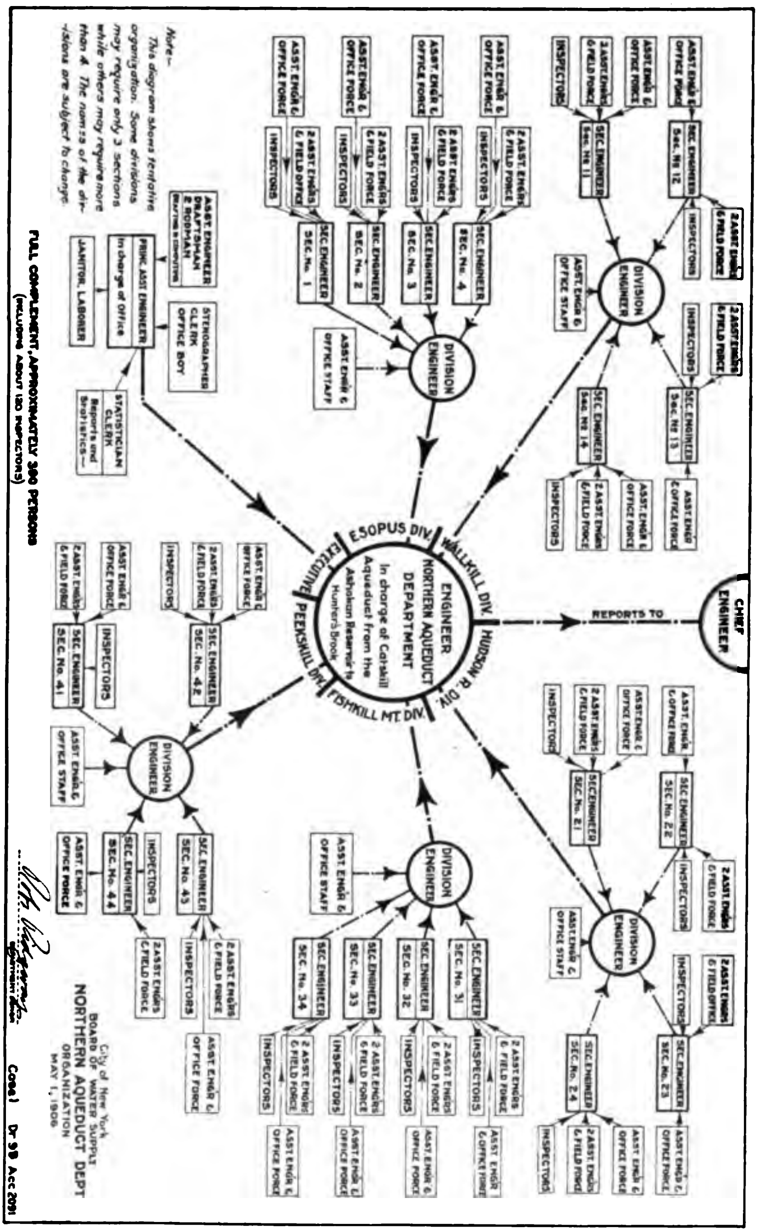
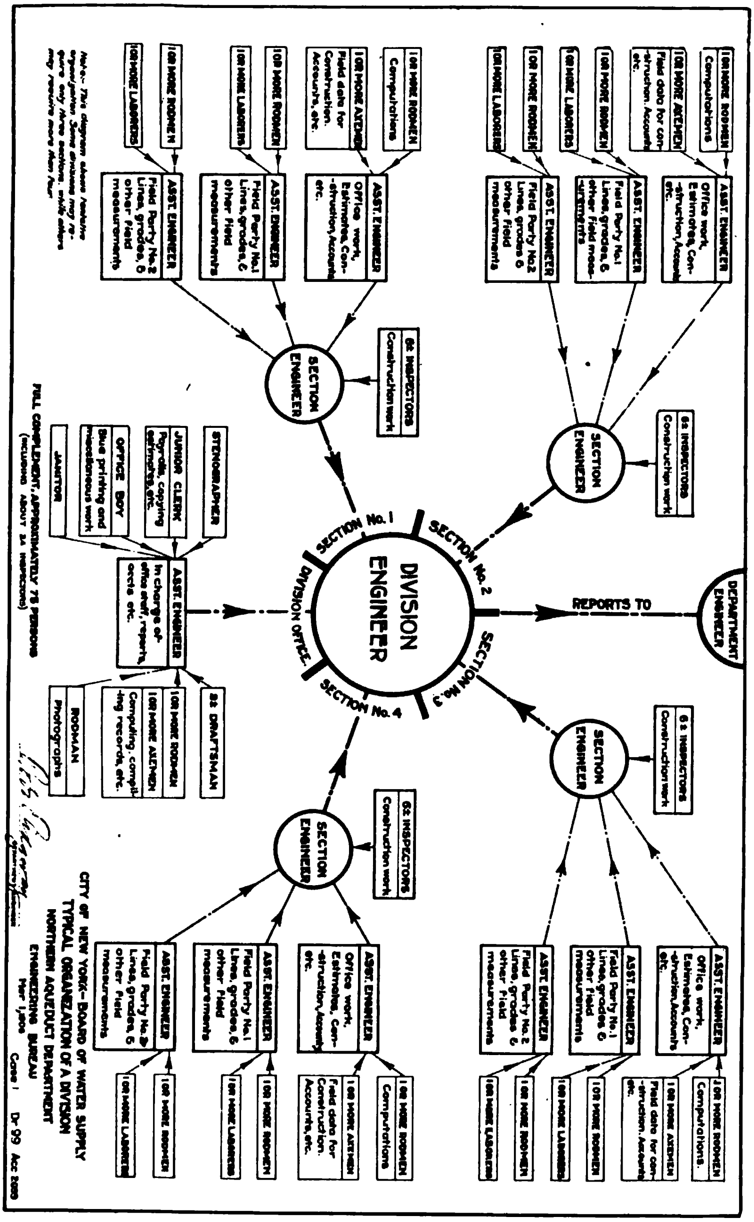


PLATE XXX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.



DISCUSSION.

MR. GEO. W. TILLSON.—Probably every member of this Society has had some idea of the wonderful work which has been done during the last year by the newly organized Board of Water Supply. The work accomplished shows better than anything else could, what can be done when the engineer is given full sway, without the obstacles which politics so frequently interposes.

The gentleman, in speaking, made reference to some enmities that may have been incurred, because the Board of Water Supply attracted unto itself some of the best men from other departments. I do not think that this is so, however, because almost all of us feel that when an engineer is given the opportunity of such valuable construction experience with the added remuneration incidental thereto, that it is for the good of the service not to play the part of a dog in the manger.

Now, I do not doubt but what there are a great many of the men present who have been engaged in this water supply work, and I know that all the members will be very glad to hear from the distinguished official, whom probably they may never have heard of before as that official—the Rear Admiral of the Navy of the Water Supply Department, Mr. Ridgway.

MR. R. RIDGWAY.—Mr. President, I think Mr. Flinn has had very little to say about himself, but he went out of his way to call me Rear Admiral. He neglected something more important, and that was his own share of the work in the organization. I don't think any one, except the Chief Engineer, had more to do with the results that have been obtained in this organization than Mr. Flinn. He has been working early and late, and intelligently, I think, and deserves a great deal more credit than I do. Outside of that, I don't think he left very much for me to say.

MR. G. W. TILLSON.—Is there any one who wishes to ask any questions of Mr. Flinn? He very kindly offered to answer any questions explanatory or elaborating anything he said.

MR. HAROLD TAIT.—I would like to hear, if possible, a little more about the laying of reinforced-concrete pipe that they anticipate putting under pressure.

MR. A. D. FLINN.—That is, perhaps, a little aside from the direct subject of the paper to-night. Preliminary studies showed that possibly as much as $1 000 000 to $2 000 000 could be saved if we can use concrete pipes up to a head of, perhaps, 100 ft., getting advantages of permanency that do not seem to be offered by steel pipes.

To prove the feasibility of carrying water under pressure—and water-tightness especially—these series of experiments were undertaken. The pipes were made 5 ft. diameter inside and 12 ft. long.

We have made ten to date; five of them are 12 in. thick and five are 5 in. thick. Each of these pipes is a double pipe, the halves being reinforced in various ways and made of different kinds of concrete as to ingredients and proportions of mixture. All concrete for such work should be wet. Some of this concrete has been mixed in a continuous mixer and delivered directly into the forms in a pretty liquid state. The pipes show differences in external appearance, due to the different kinds of aggregate and methods of compacting the concrete. It is the intention to put iron bulkheads on the ends of the pipes and then subject them to pressures up to 150 lb. per sq. in., if they will stand it. They were designed for about 65 lb. pressure in determining the strength of the steel reinforcement. Of course, we do not expect to break these pipes in that way, but to determine the leakage under various pressures, the 150 lb. being considerably in excess of the working pressure of 100 ft. head, which is the limit which has tentatively been set for the use of the pipe.

Another line of investigation undertaken was in similar work which has been successfully done by the Reclamation Service in Arizona, in connection with the Salt River project. There have been constructed four pipes 5 ft. 3 in. in diameter inside. Two of these pipes are under a maximum pressure of about 30 ft. head and have a length of 2 500 ft., and two others are about 520 ft. long under a maximum head of about 85 ft. These pipes were laid out there in the desert by Apache Indians under the direction of superintendents or foremen from the East. The concrete was mixed by hand. The gravel and sand were shoveled up from the bed of the streams, or washes, as they call them; they are dry streams most of the time. The cement was made at the site of the works in the mill built by the Government.

These Arizona pipes were made with a special apparatus developed by the engineers, called "the alligator." The inside steel form was dragged along as the concrete was placed. The outside forms consist of supporting steel rings or angles hung from timber gallows, and the wood lagging laid on diagonally. The inner face of the lagging was cut to a cylindrical surface so as to fit the pipe. The concrete is laid on the long sloping surface on the front of the pipe as the alligator progresses. These pipes were intended to be not less than 4 in. nor more than 6 in. thick, the variation being due to the slight wabbling of the alligator as it was drawn forward and to the unevenness of the lagging as it was placed on the outside. Those pipes, when first made, in some cases gave trouble by leaking, and one bad break occurred, due to an accident in the construction. That break was about 5 ft. square, in the top of one of the pipes under 85 ft. head. The hole was mended by bending the reinforcing bars back into place and fitting in a few more pieces of steel and

filling the hole with concrete. Those pipes have been in service since March of this year. When I was at the place, about the 1st of August, one of the 85-ft. pipes which was not in service was standing full of water. Measurements showed that the drop in the water surfaces at the open ends of the siphons was more than accounted for by evaporation, which is naturally high in that dry and hot climate. The leakage of these pipes was rather high at first, but steadily decreased, so that it is now believed that all the pipes are substantially tight, as tight as cast-iron pipes, or very nearly so. With those sections out there before us and the results which we hope to get from our experiments in the Seventy-ninth Street yard, we trust to show that such pipes are practicable for the work which we have in hand.

There is one other thing not mentioned in connection with our organization, which every man of the B. W. S. recognizes by this time. As you naturally see at once, in so large a force of men, with recruits coming in frequently, it is difficult to tell every new man the full detail of the organization, what he is to do and how to do it; so, during the first few months, as we thought of ways to do things, they were jotted down and ultimately a book, describing the organization and setting forth in considerable detail the methods of doing the different kinds of work, was gotten together and printed, Mr. Wisner Martin being the final editor of the book and putting it through the press.

MR. H. TAIT.—How large are these pipes that carry 150 lb. pressure and how thick is the concrete?

MR. A. D. FLINN.—There are no pipes yet carrying 150 lb. Those we expect to test to that limit are only sections 12 ft. long, some of which are 12 in. thick and the others 5 in. thick; the diameter inside is 5 ft. Those pipes out West actually in service under 85 ft. head are 5 ft. 3 in. in diameter and have a thickness between 4 and 5 in. The reinforcing steel in those Arizona pipes is $\frac{3}{8}$-in. plain, round rods, the closer spacing being 3 in. apart and ordinary spacing 6 in. in the clear. The longitudinal reinforcement is simply six $\frac{5}{8}$-in. smooth, round rods, excepting at the bends where the pipes start up the steel incline, six more rods bent to fit the curve of the pipes were added for a short distance.

MR. H. TAIT.—In your test pipes for 150 lb. are you not going to use more than a $\frac{3}{8}$-in. rod?

MR. A. D. FLINN.—Oh, yes; several different sizes; some two rings and some one. Thin pipes showed better than thicker pipes in some earlier tests. The theory which the Western people advance —and it seems a reasonable one—is that the concrete need only be thick enough to insure water-tightness (quality is of more consequence than thickness), and if the steel is to carry the load, the con-

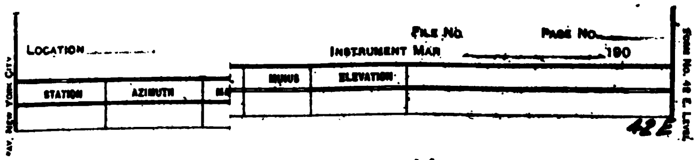
crete should not be made so thick as to interfere with that duty of the steel.

MR. M. L. BLUM.—A few years ago it was a generally accepted proposition that the engineer had no executive ability whatsoever, that his brains were simply on technical lines. Within the last two or three years there have been appointed three members of our Society in responsible charge of departments; one of them, Mr. Bensel, Commissioner of Docks; another, Mr. Tribus, Commissioner of Public Works of Richmond; and, within the last two days, Mr. Craven, in charge of the Department of Street Cleaning; but nowhere has the advantage of an engineer in charge been shown better than in this Board of Water Supply. During the last few days, in the preparation of the *Proceedings* for next year, I had occasion to visit almost every department in order to get at available lists of advertisers, and whenever I visited a department there would be a great flurry, the clerk in charge of the purchasing department would skirmish around and find a lot of tissue papers, ledgers and miscellaneous aggregation of accounts and records. In this department, the new Board of Water Supply, they have instituted a purchasing department. Mr. Purcell is in charge of that, and when I came there it was really a pleasure to see how systematically things were kept. I would like to hear from him about the details of the purchasing department; also from Mr. Wever about their details of keeping office records.

MR. PURCELL.—I do not feel justified in answering Mr. Blum at length, because my experience in this line covers only about eight months.

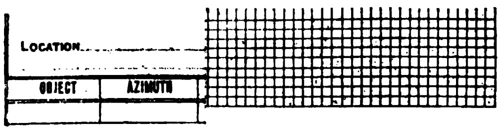
When I took my position with the Board of Water Supply I learned that I was expected to select equipment and supplies for the use of the engineers, adhering to certain standards, but always keeping in mind what the department engineers wanted; to request the chief clerk to write orders for the goods; to take care of them after they were obtained, and at the end of some stated period to report to the administration and also to the engineering heads the quantity of goods bought, used and remaining on hand. The systems I knew of for taking care of supplies were few. I consulted engineers who were connected with large works and the book systems of which they spoke seemed to be inadequate. After some little study I prepared a number of cards on which might be recorded the supplies ordered, received and distributed. After Mr. Flinn's approval the cards were installed. It would be almost impossible to describe them now, because there are a great many details in ordering and receiving goods, but we try to keep our records in such fashion on these cards that every single request coming from a department engineer is always before us until filled, and a record of

PLATE XXXI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.

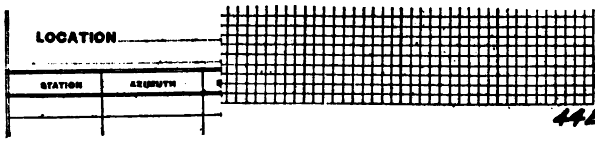


42E

42E, LEVEL NOTES.



43E



44E

PLATE XXXII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
FLINN ON THE ORGANIZATION
OF AN ENGINEERING FORCE.

FORM NO. [illegible]

______190 No.______

ACCESSION NUMBER		$ PER	INDEX UNDER	REMARKS
				121 E.

CLAIMANT ______

P. O. ADDRESS ______

LOCATION AND DESCRIPTION

OF DAMAGED PROPERTY ______

______

______

AMOUNT OF DAMAGE CLAIMED ______

" " " ENGINEER'S $

" " " APPRAISER'S

PRESENTED TO BOARD OF WATER S

SENT TO AUDITOR ______

DATE OF PAYMENT ______

PERMANENT ADDRESS ______

REPORTED FOR DUTY ______19

______ SALARY $______PER______

______ SALARY $______PER______

______ SALARY $______PER______

______ SALARY $______PER______

______19 ______19

______19 ______19

______19 ______19

______19 ______19

______19

[illegible]SCHARGED BECAUSE OF ______

______19

the transaction is kept in such shape that it can always be referred to. The original field order, as we call it, which comes from the department engineers, is filed according to the department from which it came, and then by a number which is given to it by the department engineer. For such supplies as cannot be furnished from our storeroom a requisition is written to be signed by the chief engineer or department engineer at headquarters as his attorney, asking the Administration Bureau to order the goods. They are ordered by the chief clerk, who belongs to the Administration Bureau, who likewise names the dealer. So, you see, that our division is not a purchasing division, but really a requisition division. We do not dictate to the administration the dealers from whom they shall buy, but we do stipulate the kind of goods we expect to receive.

I don't know what I can say about the facility with which we produce records as soon as they are asked for; I hope we do it, that is all.

It occurs to me that our instrument card may be interesting, since it goes much further in caring for instruments than most other records. One card, our form 83E, is written for each article of value which may be destroyed or lost and which cannot be regarded as a fixture. The face of the card bears a complete description of the article, while the back contains its history from the time it was delivered to us. A transit, for instance, would be described in full detail; its serial number and catalogue number being entered at the head of the card with the maker's name. All its details are described, such as gradienter, stadia wires, etc. Each time the instrument is moved from one place to another, the transfer is recorded on the back of the card. Whenever an accident occurs to the instrument which necessitates repairs, the nature and cause of the accident is given, the details of the repairs, and the amount paid for them. In order to limit the number of cards and to prevent the system from becoming what might be termed "fussy," a minimum of $15 is fixed as the value of equipment to be so recorded. In some cases less expensive articles are indexed because of the greater liability to loss or theft.

Purchasing is not the only work assigned to our division. Estimates for payments to contractors are prepared by us from figures submitted by the department engineers.

I will now show a number of our cards which illustrate our method of keeping records. (See Plates XXXI and XXXII.)

MR. W. D. LINTZ.—To revert back to reinforced concrete pipes. I would like to know how they intend to joint those pipes finally with the method proposed.

MR. A. D. FLINN.—As a matter of fact, the Arizona pipes were continuous without any joint from end to end. I went through

one of these pipes, when nearly completed, about a half a mile long, with the inspector, and tried to find cracks and did not find any. The first part of the pipe had been built nearly a year before the work resumed. There were two pipes in the siphon crossing the stream, and when I was there the first one was completed and the second nearly completed. When they got ready to start the second pipe they simply cleaned off the concrete previously laid, wet it very thoroughly and continued concreting the rest of the pipe. They made no provision for joints anywhere in that length. They claim the secret of their success in not finding any serious cracks was that the concrete was made wet. It was wet thoroughly as soon as the forms were removed. It was covered as soon as possible with the earth deposited in a considerable depth of water in the trench, so that the concrete had no time to really dry out. As some evidence that this was at least in part the cause of their success, I may state that when I was there the last 200 or 300 ft. of pipe which had just been built had not been covered with the earth, and they had not been able to keep it quite so wet, for lack of men, and in that last 200 or 300 ft. I found three circular cracks that went not quite around the pipe. They were very fine. If you did not have them pointed out you could hardly find them. They said they had not had such cracks elsewhere, where they had been able to follow the system prescribed by the engineer.

Whether or not we shall build pipes in that manner, without joints, is not yet settled, but we are trying to determine this by our experiments. Besides the experiments mentioned on small size pipes, it is our intention to build, under regular contract provisions, on the site of one of the siphons, a piece of pipe 11 ft. in diameter and 200 to 300 ft. long, and see what we can do with that. We are also building at the Seventy-ninth street yard a full-size model of the cut-and-cover portion of the aqueduct, which is 17 ft. high and 17½ ft. wide inside. This will be useful to contractors, showing actually what the aqueduct will be. We also intend to use it to determine the efficiency of two or three forms of joints in that kind of construction.

MR. G. W. TILLSON.—I had an opportunity a short time ago to examine some reinforced pipe that was made under a patent process which has the jointing arrangement, it seemed to me, very nicely settled. The pipes were reinforced with steel in the form of hook iron; just to what extent I don't know, but they were both circular and horizontal and the jointing was made at the ends of the hook. They were hooked and staggered 5 in. or 6 in. apart, around the pipe. Then, as the pipe came together jointed inside, there was a space on the outside for about half the thickness of the pipe and perhaps 2 in. long, where these hooks came, and through the hook on this

pipe went a circular hook around the joint that left the hook in a space in that particular pipe, which was 2 ft. or 30 in. in diameter, a space of 2 in. by 1 in., and that space was entirely filled with cement mortar. By that process they made pipes up to 6 or 7 ft. in diameter, and they told me and showed me the figures where that class of pipe had been in competition some two or three weeks ago in Baltimore with concrete pipe reinforced ordinarily, concrete pipe not reinforced, brick sewers and clay pipe, and the contractor employing this method of reinforcing pipe was the lowest bidder and received the contract. It seemed to me that the arrangement of the joints were very nicely made, as it made it practically, if not quite, as strong as the pipe itself.

MR. H. TAIT.—In filling with cement mortar was it to act as an expansion joint?

MR. G. W. TILLSON.—No; the purpose was to leave space for the insertion of the hook.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

Paper No. 28.

PRESENTED NOVEMBER 28TH, 1906.

FOUNDATIONS FOR SKYSCRAPERS IN NEW YORK CITY.

BY JOHN W. DOTY,* C. E.

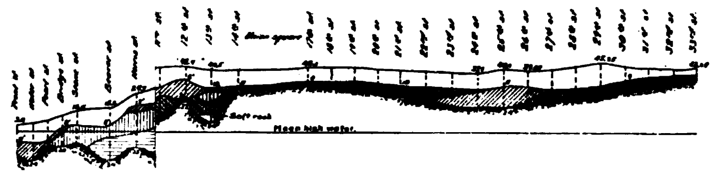
WITH DISCUSSION BY
GEORGE W. TILLSON, WINFRED H. ROBERTS, WILLIAM T. DOYLE, EDWARD A. BYRNE AND THE AUTHOR.

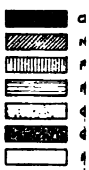
In general, examples of all classes and types of foundations can be found supporting high buildings in New York City. They can be classified and the classes subdivided as follows, in the relative order of the cost of construction, provided the conditions are favorable for the use of each particular type:

CLASS 1.—*Spread Footings*....	Concrete footings, steel reinforced concrete and steel grillage.
CLASS 2.—*Piles*...............	Wooden piles, concrete piles and steel tubular piles filled with concrete.
CLASS 3.—*Open Caissons*......	To be subdivided into piers excavated and lined with timber after excavating; piers constructed by excavation inside of sheet piling, and piers constructed by the excavation being made inside of a box which is sunk by weight as the excavation is made.

*Engineer for The Foundation Company.

PLATE XXXIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.





Note Figures on street surface give elevation above M H W.
Figures at lines of strata give distance below street surface.

OADWAY

Class 4.—*Pneumatic Caissons.* { Divided into two types—the isolated pier type and the coffer-damming type.

The conditions governing the selection of the most economical type of foundation for any particular site are principally:

1.—The elevation of the rock below the general street level.

2.—The magnitude of the loads to be supported and the manner in which they are distributed.

3.—The value of the structure to be supported.

4.—The nature of the soil on the proposed site.

5.—The elevation of the water on the proposed site.

6.—The depth of the general excavation for the sub-basements.

7.—The conditions on the adjoining property.

8.—The risk of possible disturbance of the soil on the site due to adjoining constructions.

It can be seen from the above tables on account of the number of different classes and types of foundations used in New York City, and the number of conditions limiting the selection of the most economical type, that the relative advantages and disadvantages of each type for any particular combination of conditions cannot be reasonably set forth.

Plate No. XXXIII shows a section of the rock basement of Manhattan along the line of Broadway from the Battery to Thirty-third Street. It also shows clearly the nature of the material encountered from the surface of the street to rock. For this section I am indebted to Mr. William Herbert Hobbs, of the Department of the Interior, U. S. Geological Survey.

You will notice north of Union Square, or Fourteenth Street, that the rock lies very close to the surface of the ground. There are exceptions to this general rule where the beds of old water courses are encountered.

Between Thomas Street and Fourteenth Street the rock varies in depth from 20 to 140 ft. below the surface of the ground. The material overlying the rock is principally coarse sand and gravel with a little fine sand, but in general no quicksand is present.

From Thomas to Fulton Streets you will notice that the rock is from 81 ft. to 140 ft. below the general ground surface. From

the surface down is found a coarse or fine sand, except for a thin stratum of quicksand overlying the rock. This quicksand is, however, about 90 ft. to 100 ft. below the general ground surface.

From Fulton Street to Stone Street the rock is from 35 ft. to 85 ft. below the general ground level. You will notice that the material is principally fine sand and quicksand.

Now, let us review the list of the skyscrapers in New York City, found in the different sections of the city, as above subdivided by the nature and location of the material found in it, and also review the class and type of foundations supporting them. Above Fourteenth Street are the Times Building, Belmont Hotel and the Flatiron Building. All of these buildings are supported on rock which was found, in general, near the street surface. Some of the excavations for the sub-basements were made in the rock. This type of foundation is general for the support of high buildings in this section of the city.

Between Thomas and Fourteenth Streets there are no skyscrapers; the high buildings in this section are in general supported on spread footings, the soil being coarse sand and gravel and capable of supporting safely the loads imposed by the type of building constructed in this locality.

Between Fulton and Thomas Streets the Park Row Building is probably the most striking example. This building is supported on wooden piles driven into coarse sand. About 100 ft. below the general street level the quicksand stratum is encountered. The St. Paul and Barclay Buildings are on spread footings, the Barclay Building rests on coarse sand, the St. Paul Building on a fine sand. These three buildings are the highest in this section. The other high buildings are supported generally on spread footings.

Below Fulton Street we encounter fine sand and quicksand. We have in this section the following high buildings: the Trinity, U. S. Realty, Empire, Standard Oil, No. 42 Broadway, Whitehall, Manhattan Life, Wall Exchange, Broad Exchange, Commercial Cable, Trust Company of America, American Surety, U. S. Express, International Banking, Blair Building, Hanover National Bank and the Whitehall Building. All of these skyscrapers and such monumental buildings as the Stock Exchange, the Custom

House, Seligman Building and the Royal Queen Insurance Building are founded on pneumatic caisson piers sunk to rock. The skyscrapers as listed above have from 20 to 26 stories and are from 260 to 320 ft. in height above the curb. The Singer Building, now under construction below Fulton Street, will have 41 stories with an approximate height of 620 ft. above the street level. The foundations for this building are pneumatic piers carried to rock. The greater number of buildings having up to 16 stories in height and one building having 20 stories in height, are resting on spread footings, the most noted example being the Maiden Lane Building. The West Street Building has 22 stories and is founded on wooden pile foundations. The building at No. 1 Wall Street has 16 stories and is founded on steel tubular piles filled with concrete. The Produce Exchange Bank Building has 12 stories and is founded on concrete piles. These last three are the only buildings of their height that are founded on these particular types of foundation in the lower part of New York.

It will be readily seen, although we have examples of almost all types of foundations in the lower part of the city, that with few exceptions the buildings having 16 stories or more and the expensive monumental buildings are founded on pneumatic pier foundations carried to bed-rock. As there are few skyscrapers in the other sections of the city, it can be reasonably stated that pneumatic foundations are used for practically all the skyscrapers in New York City.

To thoroughly understand the conditions governing the necessity of the use of the pneumatic method for the construction of the foundations, it will be best to select a typical example showing the requirements and conditions presented for consideration when designing the foundations for a skyscraper. We will take, for example, the building just constructed for the Trust Company of America, at 37-41 Wall Street. This building has a frontage on Wall Street of about 61 ft., a depth of about 125 ft. and a total area inside of property and building lines of 8 316 sq. ft. The building has 26 stories and a total height from the curb to the roof of about 320 ft. The conditions to be considered are as follows:

1.—The rock was found by borings to be from 47 ft. to 50 ft. below the Wall Street curb.

2.—The total weight of the building is approximately 42 000 000 lb. This load is concentrated on the footings of 25 columns, each column carrying from 1 500 000 to 2 700 000 lb.

3.—The building represents an investment of about $2 000 000.

4.—The material found overlying the rock was a fine sand to the depth of 15 ft. below the curb. From 15 ft. to 45 ft. quicksand was encountered, and below this depth to rock there was from 3 ft. to 5 ft. of hardpan.

5.—The local water level is 15 ft. below the street curb.

6.—The general excavation for the sub-basements is carried over the entire lot to a depth of about 34 ft. below the curb.

7.—The conditions on the adjoining property are as follows:

On the east side there is a 9-story and basement building resting on spread footings at a depth of about 13 ft. 6 in. below curb. On the west side there is an 11-story building and basement on spread footings at a depth of about 13 ft. below the curb. On the south side there is a 24-story building (the Wall Street Exchange), which is supported on pneumatic caisson piers carried to rock. The buildings on the south and west are of a type of construction built in New York from 15 to 20 years ago. The exterior walls were self-supporting and built out to the property line, the wall in the basement being 3 ft. thick and the footings supporting these walls are 9 ft. wide. The interior columns are supported by independent footings.

8.—New buildings are likely to be constructed on both the east and west side of this site and it is not improbable that a subway will be built in the street. These constructions would likely disturb the soil on this site.

Before discussing the advantages of each class and type of foundation for this building, let us firmly fix in our mind what quicksand is and how it acts. Quicksand is a very fine sand saturated with water. It follows, in general, the laws governing the flow of fluids and will go through any crack or crevice that water will and it will always try to reach a general level.

As the value of the building represents an investment of $2 000 000, it is extremely important that the foundations will not settle. A settlement would probably cause a great deal of damage to the building, reducing its rental and real estate value. It

is necessary from a business point of view to insure a building of this value against any possible settlement. We must then consider what class and type of foundation will meet the conditions to be found on this site, and which will not settle under the superimposed loads.

Let us consider briefly the advantages and disadvantages of the different types of foundations to meet the conditions presented. On account of the general excavation being carried to a depth of about 34 ft. below curb, the underside of the footings of any type could not be less than 38 ft. below the curb. At this level we encounter nothing but quicksand. Let us consider the adaptability of a spread footing design for the support of this building. If the total weight is distributed uniformly over the total area of the lot, the soil would be loaded at the rate of about 2½ tons per sq. ft. It would be extremely expensive and impractical, due to the arrangement of the columns, to construct a foundation which would equally distribute the load over the entire area. If the building was founded on spread footings constructed in a practical manner there would be a certain area of the soil loaded at the rate of about 9 tons per sq. ft. The quicksand is not capable of supporting this load. It is capable of supporting safely only 2 tons per sq. ft., if it is confined, and therefore this type of foundation is not adaptable for this building.

If the loading on the soil was within the allowable rate it is extremely important to consider whether the quicksand under the footings would be disturbed by adjoining constructions, thus causing a settlement which would not only reduce the real estate value of the building, but might injure it so seriously as to weaken the structure beyond the degree of safety. In general, on account of the probability of settlement it is very poor policy to found an expensive building on spread footings resting on quicksand.

Let us consider wooden piles for the support of this building. If piles are driven at 20-in. centers, which is the minimum spacing allowed by the Building Department, the load on certain piles would be about 25 tons per pile, which is greater by 5 tons than the load allowed by the Building Department. If the load could be properly distributed on piles spaced on 20-in. centers there are a great many other points that must be considered before they are

driven into quicksand for the support of an expensive building. The nature of the material is such that the frictional support of the pile should be ignored; if the piles do not reach a good firm stratum (in this case the hardpan or rock) they would float in the sand and would offer very little more protection to the building against settlement than a foundation of the spread footing design. In driving piles at 20-in. centers the first few piles might reach a firm stratum, but as each successive pile is driven the soil becomes more and more compact, and the result is that probably not more than half the piles reach a firm bearing, the others being held by the friction of the compacted soil. Moreover, a great many of them are likely to be broken by overdriving. In general, it is safe to say that only 50% of the piles will reach hardpan or rock bottom. In case of any disturbance due to construction on adjoining property, the compacted soil around the piles (which in this case is quicksand) will be relieved and the building would then be supported on probably half the total number of piles driven, or each supporting pile will have a loading of about twice the allowable load per pile. All wooden piles must be cut off below water level. The elevation of the local water level on any particular site cannot be maintained. In this section of the city most of the high buildings have deep sub-basements (some of them going to hardpan at a depth of 50 ft. below the street level). These buildings have a pumping system which lowers the local water level in their immediate locality. The construction of subways and tunnels is also affecting the sub-drainage. There are several cases where one or both of these causes has lowered the water level considerably below the level of the tops of the piles, thus exposing them to decay. In general, on account of the uncertainty of the water level and the difficulty of driving piles spaced at close centers through quicksand to a firm bearing, it is inadvisable to use this type of construction to support an expensive building.

Let us consider concrete piles. It is impracticable to jet down a number of built-up piles in quicksand without displacing enough material to endanger the adjacent buildings. Piles built in the ground, such as the Simplex or Raymond concrete piles, cannot be driven safely closer than 3 ft. center to center. This would

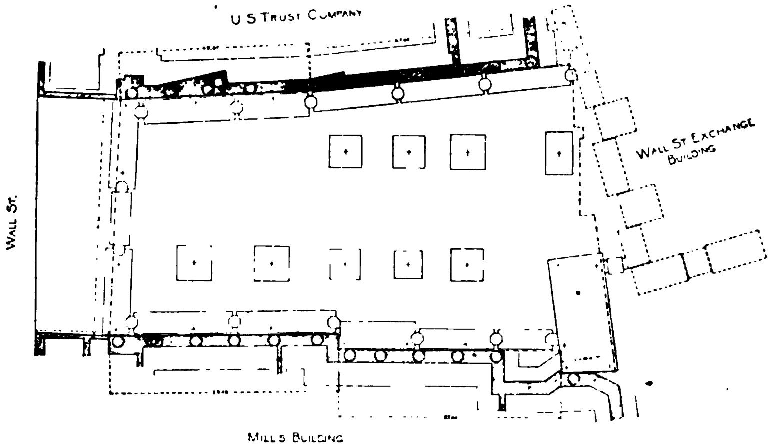


FIG. 1.—SHOWING EXTENT OF PROPERTY AND WALL FOOTINGS OF ADJACENT BUILDINGS.

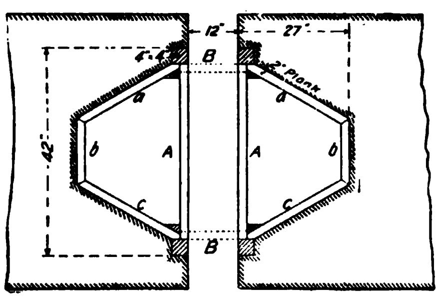


FIG. 2.—SECTION OF JOINT BETWEEN TWO CAISSONS.

give a loading on a standard 16-in. diameter pile of 81 tons. The maximum load allowed by the Building Department is 35 tons per pile, or 350 lb. per sq. in. on the section of concrete when the pile is reinforced with steel.

Foundations supported by steel tubular piles with a concrete core could be put in place to carry the loads of this building based on the present Building Department allowance, namely, 6 000 lb. per sq. in. on the steel shell and 500 lb. per sq. in. on the concrete section. Take, for example, a 12-in. diameter steel pipe $\frac{3}{8}$ in. thick. The allowed loading would be approximately 83 400 lb. on the shell and 50 000 lb. on the concrete, or a total load of 133 500 lb., or 66.7 tons, of which about 37% is on the concrete and 63% on the steel shell. The frictional value of the pile in quicksand should be ignored, which means that the loading on the material on which the pile rests would be at the rate of 86 tons per sq. ft. The steel shell is not protected from corrosion or from other deteriorating elements such as electrolysis, gases, etc., which leak from the numerous pipes, sewers and conduits laid in the streets in this section of the city. In case the steel weakens or is reduced in section, in all probability the concrete would eventually have to support the full allowable load of 133 500 lb., or the concrete would be loaded at 1 350 lb. per sq. in., which is an unsafe bearing value for concrete, not taking into consideration the factor of safety that ought to be allowed for the concrete acting as a column. Another objection to this type of pile is the uncertainty of getting it down to good rock, which must be reached in order to support the load. Rock in this section of New York City is covered by from 2 to 20 ft. of hardpan. This material is composed of a cemented mass of gravel, clay and sand. The gravel consists of stones from the size of a pea to boulders of about 4 cu. yd. In case a large obstruction is met while driving the pipe through hardpan, it is almost impossible to get by it, and it would be extremely expensive to drill through, hence the pipe is left to rest on a boulder of unknown size, which must carry the full load of the pipe. Many claim that as long as the steel tube is cut off below water level practically no deterioration can take place, but as in the discussion on wooden piles it was shown that the water level may be lowered, exposing them to decay, the same ob-

jection will hold with steel tubular piles. If the loading on the shell is ignored the pile reduces to a concrete pile, which type of foundation has been discussed above. For these various reasons it is decidedly unwise to construct expensive or heavy buildings on this type of foundation using the loads allowed by the Building Department.

From the discussion of Classes 1 and 2, it will be seen that it is necessary to be assured that the footings of this building are rock, if we desire to guard against any possible settlement. Let us consider Class 3, the open caisson foundations. It is impossible to drive sheet piling below the water level through quicksand as found on this site and have it tight enough to keep the water from leaking through, or from coming up inside of the box and carrying with it considerable sand. The displacement of this sand would very quickly cause a settlement of the adjoining property. A great many open methods have been tried for constructing a pier to rock through quicksand, but have failed because of the displacement of the material during the pumping operations, causing serious damage to the adjoining buildings.

Let us consider the pneumatic caisson method. This method of constructing a pier through quicksand to rock is by using an air pressure inside the caisson equal to, or greater than, the exterior pressure caused by the water or material surrounding the caisson and by this pressure hold the surrounding material in place, enabling the pier to be founded on clean firm rock without loss of material. Although it is stated that the pier can be constructed by the pneumatic method without the loss of material, which is true, we must not overlook two causes which disturb slightly the soil directly next to the sides of the caisson, the first being the dragging down of the material which comes in contact with the side of the caisson when it is settling. The second, partly offsetting the first, is that due to the air, which leaks from the working chamber and comes up alongside of the caisson and has a tendency to lift the soil directly adjacent to the caisson. Although the material is not lost, it is undoubtedly disturbed immediately adjacent to the sides of the caisson, the distance being governed by the nature of the material and the care used in executing the work. The pneumatic method of constructing the founda-

PLATE XXXV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.

TRUST COMPANY OF AMERICA BUILDING AND VIEW OF ADJACENT BUILDINGS.

tion, although being the most expensive, is the only one by which a pier can be safely carried through the quicksand to rock without disturbing the soil to such an extent as would damage the adjoining property. As this class of foundation can be carried to bed-rock without the loss of material and absolutely insures the building against damage from settlement, it is the only practicable one for this building.

Although we have considered the advantages and disadvantages of the different classes and types of foundations applied to the conditions that exist on the site of the Trust Company of America Building, it would be well, in making the general excavation, to make a general analysis of the conditions which this building presents.

The general excavation has to be carried to a depth of 34 ft. below the curb level, which is through 19 ft. of quicksand, 19 ft. below the water level and about 21 ft. below the footings of the adjoining buildings. It is impossible to make this excavation to the required depth by any open method, for the same reasons given above against the use of the open caisson method; this, therefore, applies similarly against coffer-damming the lot with sheeting. For this reason, in order to do the excavation required, it is necessary, first, to construct a pneumatic coffer-dam on the property lines of this lot, carrying the coffer-dam down to hardpan or rock before any excavation is made below the footings of the adjacent buildings. Not only is it necessary that the foundations of this building be constructed by the pneumatic method, but that a coffer-dam constructed by the pneumatic method be used to safely make the general excavation to the required depth.

Since we have to construct a pneumatic coffer-dam to rock around the exterior lines of the lot, this coffer-dam can be increased in width, if necessary, to support the exterior columns of the building, and since the coffer-dam sunk to rock cuts off any possible flow of material from the adjoining property, the piers supporting the interior columns of the building can be safely constructed by the open caisson method.

Plate XXXIV shows the extent of the property on which the Trust Company's building was built and the footings of the walls of the adjacent buildings; it also shows clearly the column centers

of the new building. It will be noticed that some of the exterior columns are within 18 in. of the property lines, and on account of the loads that they support it was necessary to properly distribute the loads to cantilever. The pneumatic coffer-dam is carried along on the east, west, north, and partly on the south side of the lot. The ends of this coffer-dam on the south are keyed to the concrete coffer-dam which forms the foundations for the exterior columns of the Wall Street Exchange Building. The thickness of the walls of the coffer-dam is in no case less than 5 ft., and where it supports columns the width is governed by the area required to support them. The piers supporting the columns are founded on rock, the size being governed by the allowed load of 15 tons per sq. ft. on the area of the concrete.

Now let us consider briefly the different steps taken in constructing the foundations as designed:

Plate XXXV shows the new Trust Company of America Building and the adjacent buildings which had to be shored to prevent any possible settlement, while the pneumatic coffer-dam was being constructed. The building on the west has 11 stories and the building on the east 9 stories. The weight per lineal foot on side walls is from 25 to 30 tons for each building. The walls in the basement are 3 ft. thick; the footings are 9 ft. in width, and are very eccentrically loaded, the maximum pressure on the outside edge of the footing being about 10 tons, or 8 tons in excess of what the soil is capable of safely supporting. On account of this excessively eccentric loading it was necessary to shore the walls of the adjacent buildings before the old buildings on the site were removed. This shoring was done (as shown on Plate XXXVI) by cutting niches through the basement walls of the old buildings and into the basement wall of the adjoining building, and sinking to rock pneumatic shoring cylinders directly under the center of the wall. This method of shoring was adopted because it would not permit settlement during the sinking of the caisson, and because all the shoring material was kept inside of the property line so as not to interfere with the sinking of the pneumatic coffer-dam which came as close as possible to the face of the wall. This method did not require access to the adjoining building and did not disturb the tenants or heavy machinery.

PLATE XXXVI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.

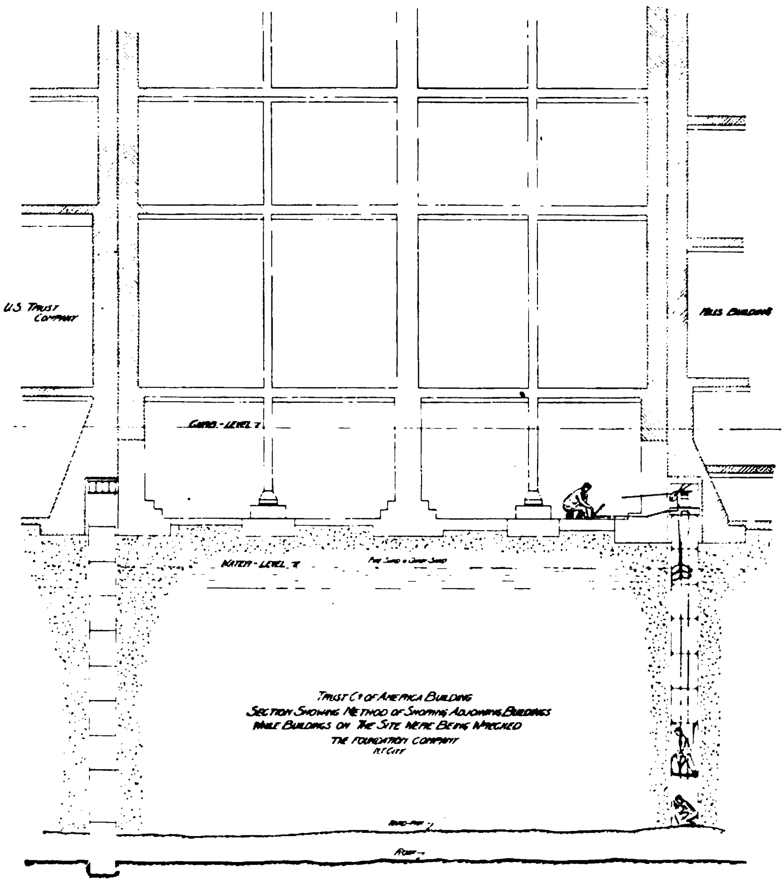


PLATE XXXVII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.

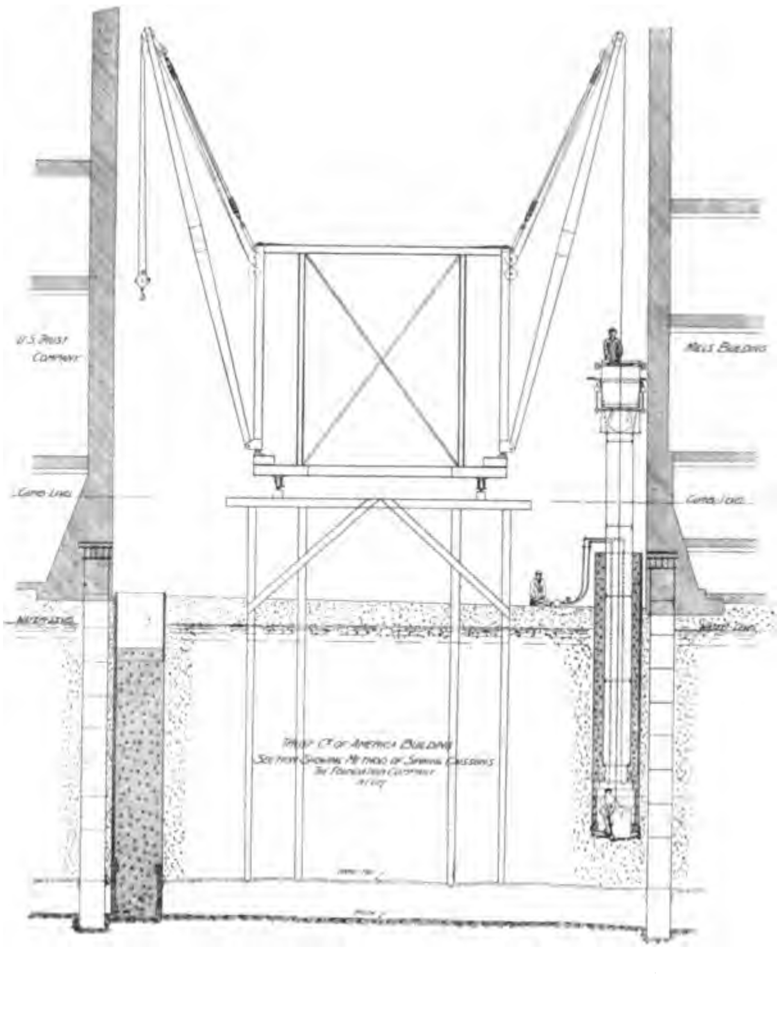


Plate XXXVI shows a section through the old buildings on the site and the adjoining buildings during the operation of shoring and underpinning. On the right-hand side is shown a shoring cylinder 3 in. in diameter being sunk to rock; the lower 6 ft. section is the working chamber, the 6 ft. section above it is fitted up as an air-lock, and all of the other sections above the air-lock act as a coffer-dam and help support the building when the cylinder is finally in place. The shells are $\frac{3}{8}$ in. in thickness and the joints are faced so that each shell has a true bearing on the one below. The cut also shows the pipe lines supplying air to the working chamber, and the gauge tender regulating the amount of air supplied. It will be noticed that the air is delivered direct to the working chamber. The man in the working chamber fills small canvas bags with the excavated material and lifts them up to the man in the air-lock (the upper door being closed). After a certain number of bags are stored in the lock the lower door is closed and the upper door opened and the bags hoisted to the cellar level. The left-hand side of the cut shows a cylinder sunk to rock and completely filled with concrete and capped with I-beams grouted into the wall.

Plate XXXVII shows a section through the lot during the sinking of the concrete coffer-dam wall. This wall was divided into sections or caissons of convenient lengths, varying from 17 ft. to 30 ft. Each section was sunk independently to rock, and after all the sections or caissons were in place a concrete key constructed by the pneumatic method filled the space between the caissons. On the right side of the cut is shown a caisson being sunk to rock. The working chamber at the bottom is constructed of heavy timber and is about 6 ft. in height. On top of the timber working chamber is moulded a pier of concrete, the height being estimated for each particular section so as to bring the concrete below the elevation of the underside of the grillage beams when the caisson reaches rock. Through this pier of concrete is shown the shaft for the purpose of removing materials from and to give access to the working chamber. On top of the shaft is the air-lock, which forms a lock between the atmospheric pressure and the greatly increased pressure in the working chamber. Air is supplied directly to the working chamber by pipes built in the con-

crete, the supply being regulated by the gauge tender. On the right of the cut is shown a caisson sunk to rock, the working chamber and shaft being filled with concrete, making a solid concrete pier from the rock to the undersides of the grillages. It will be noticed that the general excavation was carried down to the depth of the footings of the adjoining buildings before the caissons were sunk and that all the sinking was done from this level, which is also at the approximate elevation of the water level.

Where the elevation of the top of the concrete in the caisson came below the footings of the adjoining buildings, it was necessary to construct heavy timber coffer-dams to prevent dislodging the material from under the adjoining footings.

Plate XXXVIII shows the actual sinking of a caisson along the east side of the lot. At the lower left-hand corner is shown a caisson that has been sunk to rock. The top of the concrete being a few feet below the footing of the adjacent buildings, a timber coffer-dam was used. The second caisson is being sunk; the two men on top are the lock tenders; the heavy blocks of cast iron which are piled on top of this caisson are for the purpose of weight. This weight is necessary to overcome the upward pressure of the air and the friction on the sides of the caissons. On this cut also can be seen the caps of two shoring cylinders which do not project beyond the property line and permits the sinking of the caisson against the face of the wall.

Plate No. XXXIX shows a section through the lot after the pneumatic coffer-dam and all open caissons for the interior piers have been sunk. It also shows the lot excavated down to its final grade and the method of the cross-lot bracing for the purpose of holding the adjacent buildings and the tops of the caissons from moving until the permanent steel was erected.

Plate XL, Fig. 1, is a section through the completed building and shows that the permanent steel and floors act as a cross-lot bracing.

The above discussion on the design and construction used in connection with the foundations for the Trust Company of America Building is typical for large buildings in this section of New York having basements considerably below the water level. Where the general excavation for the basement or sub-basement

PLATE XXXVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.

VIEW SHOWING ACTUAL SINKING OF CAISSON.

is above the water level, sheet-piling is tight enough to hold the material until the permanent basement walls are constructed. The piers are designed to support the columns and are carried independently to rock by the pneumatic method.

Let us consider briefly the design and construction of the foundations for a building of this type: Plate XL, Fig. 2, shows the foundation layout for the U. S. Realty and Trinity Buildings. The general excavation for these buildings was made over about two-thirds of lot down to a depth of about 26 ft. below the Broadway curb, the remaining area was excavated to a depth of 30 ft. below the curb, the adjoining property being protected by sheeting. Water level was found at about 26 ft. below the curb. The Trinity Building foundations were constructed in 1904, and consisted of 50 caissons, each supporting one or two columns. In 1906 the Trinity Annex was built, the additional foundations being 17 caissons along Thames Street. The U. S. Realty Building foundations were erected in 1906, and consist of 70 caissons which were constructed at the same time as the work on the Trinity Annex. The caissons for both of these buildings rest on hardpan or rock found at an average depth of about 80 ft. below the Broadway curb level.

Plate No. XLI shows the condition of the work on the U. S. Realty and Trinity Annex on May 31st, 1906, three days after the lot was turned over to the foundation contractor. The old buildings were wrecked to the curb level some time previous to the awarding of the foundation contract.

Plate No. XLII was taken on June 30th, 33 days after the work was commenced. It shows part of the plant which handled the work; most of the pneumatic plant, temporary building, etc., was installed under the platform which ran from Broadway to Greenwich Street and formed a temporary surface for Thames Street.

Plate XLIII shows the condition of the work on July 14th, and the progress made in 47 days' time.

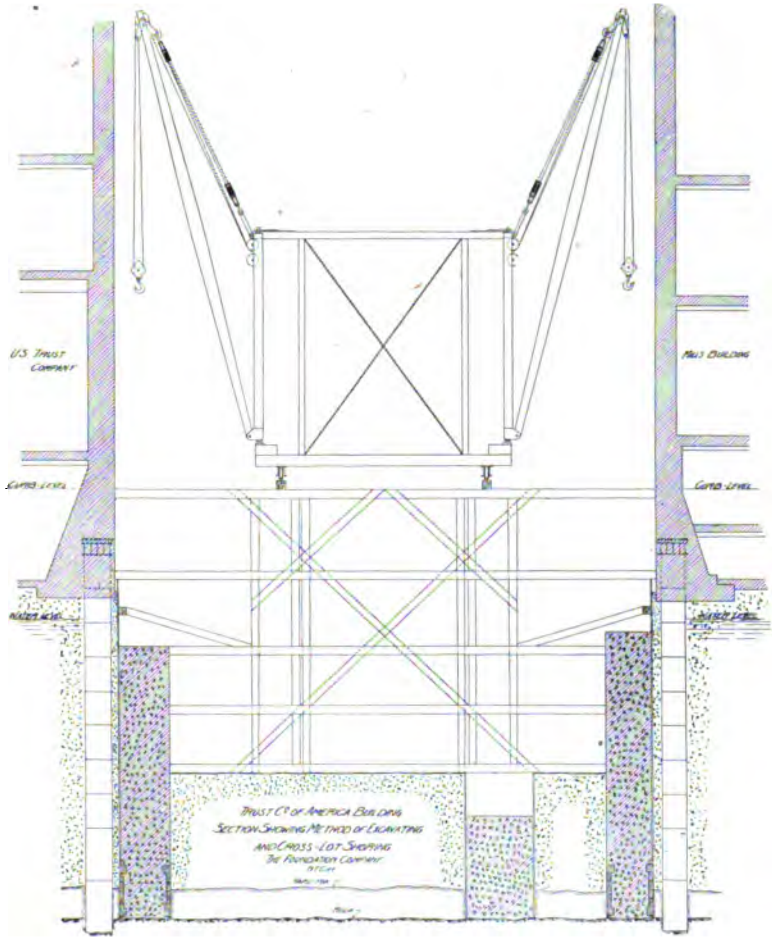
Plate XLIV shows the condition of the work on August 28th, 90 days after the work commenced.

The foundation work, including the general excavation, street sheeting and shoring, was done within 100 consecutive days; the con-

struction of the 87 pneumatic caisson piers was done in 60 consecutive working days.

All the foundations in the lower part of New York present their own peculiar conditions, but in general the two pieces of work above referred to are typical of their respective kinds and show the extremely complicated conditions to be overcome in designing and constructing the foundations for skyscrapers in New York.

PLATE XXXIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.



DISCUSSION.

Mr. G. W. Tillson.—The paper is on a subject that does not come strictly in the line of our business, but on account of the relation that foundation work has with general engineering for municipal purposes in New York, it has a peculiar interest to us. I have no doubt that Mr. Doty will be glad to answer any questions, and we would also appreciate discussion from the members who have had experience in similar construction.

Mr. Roberts.—In case a pneumatic caisson coffer-dam surround a deep excavation, what is the method of making the joints tight between the caissons?

Mr. Doty.—Plate No. XXXIV, Fig. 2, shows in general the section of a joint between two caissons. The caissons are sunk with a space of about 15 in. between them. The concrete forming the caisson is cored out by the forms *a, b, c,* and *d.* The 4 by 4-in. timbers are anchored back into the concrete. When the joint is finally completed all of the timber except the 4 by 4 and a short piece, *B,* is removed and the section completely filled with concrete. The method of making the joint is as follows:

After both caissons are sunk to the final level and the working chambers concreted, a short piece of shafting is set into the space cored out for the joint, and is concreted in place. On top of this section of shafting the air-lock is placed. Air is then turned into the lock and the sandhogs remove the concrete form timbers *a, b, c,* and *d,* and put in place the timber *B,* at the same time excavating the material between the ends of the caissons and the pieces *BB.* This method is carried out until hardpan or rock is reached; then the joint is completely filled with concrete, which is lowered through the air-lock.

Mr. Doyle.—I would like to ask Mr. Doty how they take out the shafting, connecting the working chamber with the air-lock, when it is below water level?

Mr. Doty.—The top of the concrete of a caisson is usually above water level. When it is not above water level a heavy cofferdam is constructed from the top of the concrete to a height above the water line. The concrete of the caisson through which the shaft is built and the working chamber concrete at the bottom are practically water-tight. These conditions permit men to be lowered down the shaft, after air has been taken off, to remove the collapsible steel shafting. In some cases there is water in the lower portion of the shaft, but this is removed by a steam syphon.

Mr. Byrne.—I would like to ask the average cost per yard of finished caisson work in the city, say, carried to a depth of 50 ft. below water level.

Mr. Doty.—The cost fluctuates considerably with each combination of conditions and a figure applies only to one site. In general, it costs from $40 to $50 per cubic yard for the average city caisson work, although it is likely to cost twice as much—dependent entirely on specific conditions.

Mr. Byrne.—Would that cost cover a pier having a section of 3 ft. by 6 ft.?

Mr. Doty.—The above cost would not cover a caisson having this area, as it is based on a caisson large enough to allow the men in the working chamber to work conveniently around the bucket.

Mr. Byrne.—Do you carry the air pipes supplying the air to the working chamber through the caisson shafting or outside of it?

Mr. Doty.—The air pipes are carried outside of the caisson shafting and are built in the pier.

Mr. Byrne.—In the caisson shafting is there sufficient clearance to enable a caisson bucket to pass a man when he is ascending or descending the shaft?

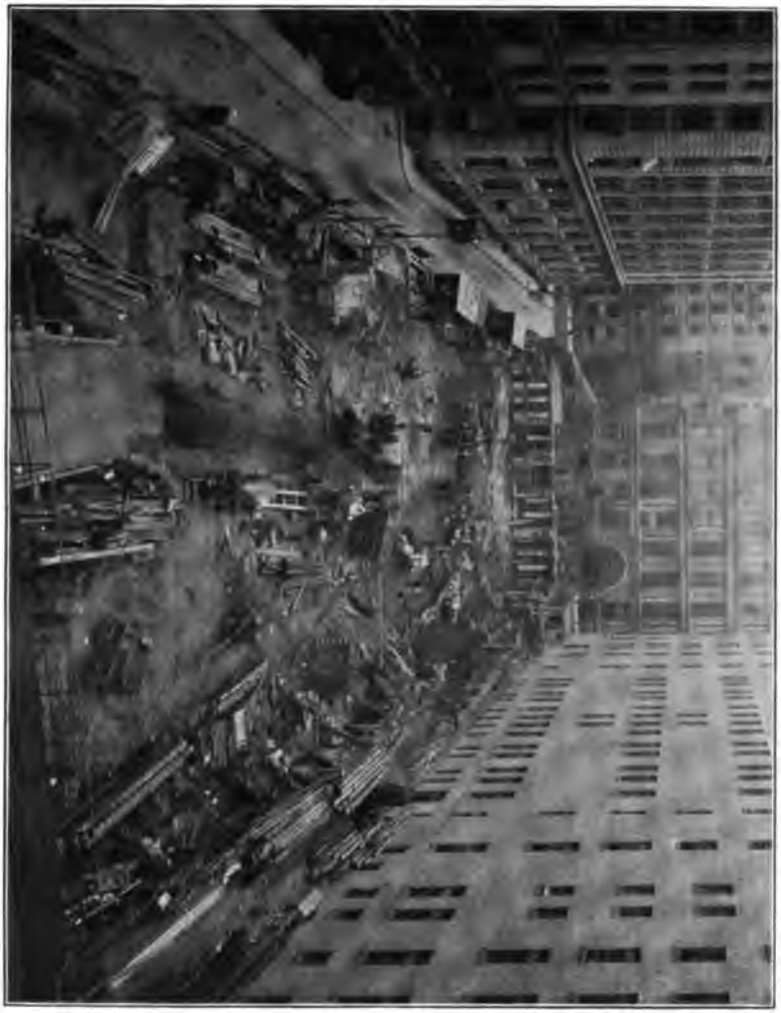
Mr. Doty.—We have two types of caisson shafting—the one 30 in. in diameter for small caissons, and the other an oval shaft 30 by 54 in. As the small circular shaft is not large enough to permit a bucket and a man to go up or down the shaft at the same time, a locking device is used which will not permit a bucket to be lowered when a man is in the shaft. The oval shaft, which is used most of the time, is designed to give the workmen and the bucket each independent compartments so as to eliminate any chance of accident.

Mr. Byrne.—Do you use air pressure to operate your machinery for hoisting material and operating the locks?

Mr. Doty.—In general, air pressure is not used for the operation of the machinery. Machinery could be constructed to be operated by the air pressure from the compressors installed on the work, but it would have to be especially designed to operate under a low pressure, which would make this machinery of very little use for general contract work. All the material is hoisted by derricks which are operated principally by steam hoisting engines. The air-lock requires no special machinery for its operation.

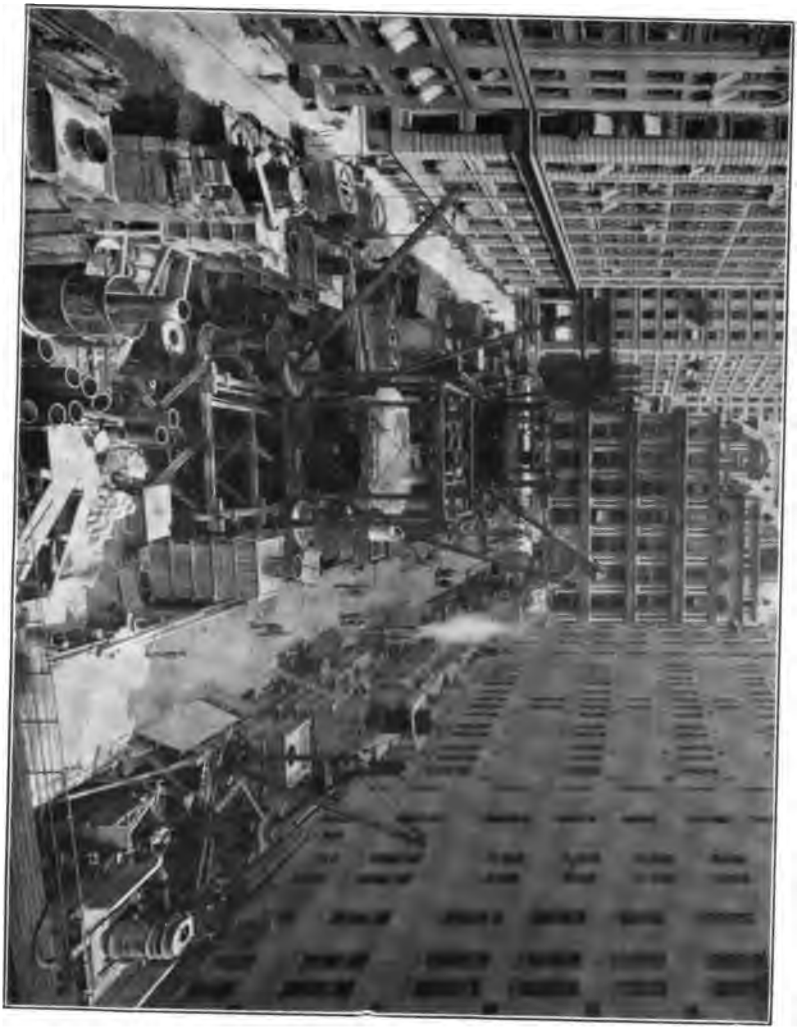
Mr. Byrne.—How many hours do the men usually work in the caisson?

Mr. Doty.—In sinking to a depth of 50 ft. below the water level the men work 8-hr. shifts, this time being divided into 4-hr. periods, with 1 hr. between each period.



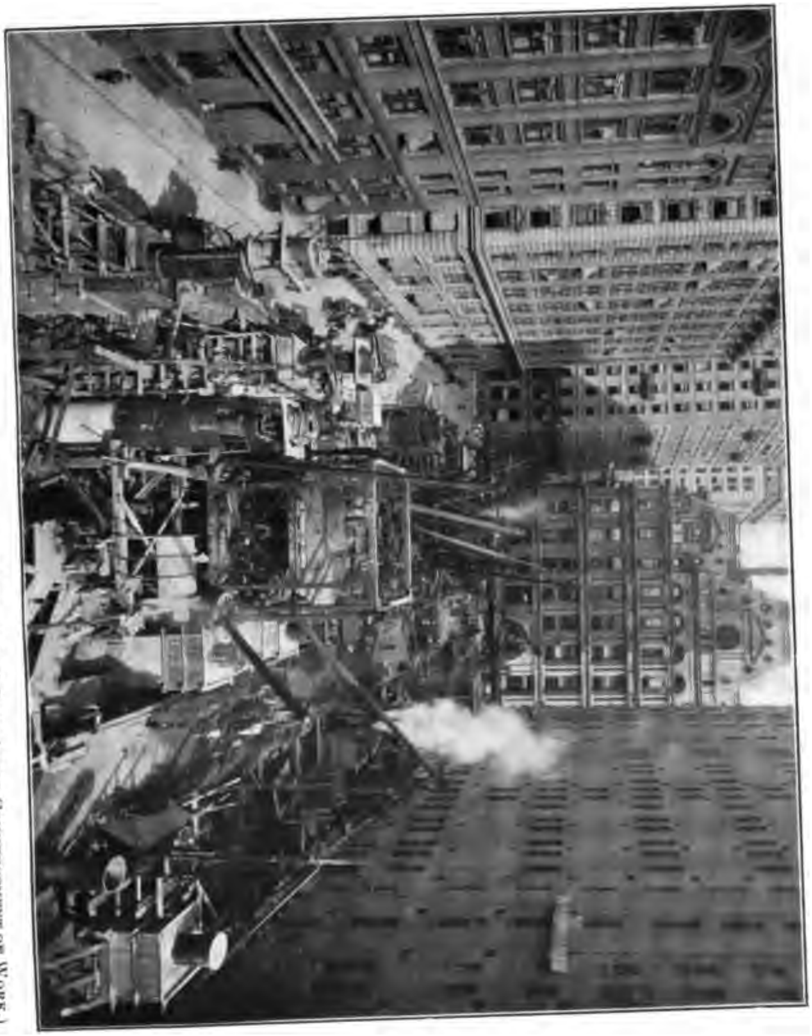
PROGRESS ON U. S. REALTY BUILDING AND TRINITY ANNEX, MAY 31ST, 1906 (8 DAYS AFTER COMMENCEMENT OF WORK).

PLATE XLII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.



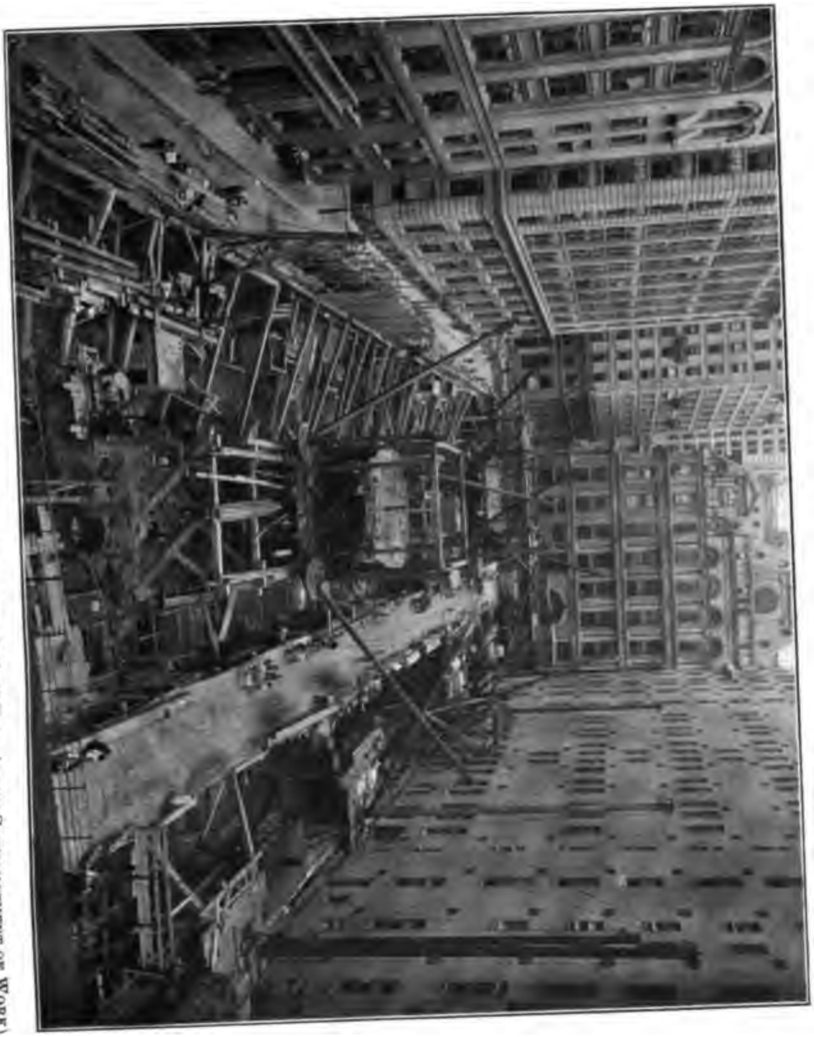
PROGRESS ON U. S. REALTY BUILDING AND TRINITY ANNEX, JUNE 30TH, 1906 (38 DAYS AFTER COMMENCEMENT OF WORK)

PLATE XLIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.



PROGRESS ON U. S. REALTY BUILDING AND TRINITY ANNEX, JULY 14TH, 1906 (47 DAYS AFTER COMMENCEMENT OF WORK.)

PLATE XLIV.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
DOTY ON FOUNDATIONS FOR
SKYSCRAPERS.



PROGRESS ON U. S. REALTY BUILDING AND TRINITY ANNEX, AUGUST 29TH, 1906 (90 DAYS AFTER COMMENCEMENT OF WORK).

THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.

Paper No. 29.

PRESENTED DECEMBER 26TH, 1906.

TUNNELLING UNDER COMPRESSED AIR WITH SHIELDS.

BY ST. JOHN CLARKE,* M. AM. SOC. C. E., MEMBER OF THE SOCIETY.

WITH DISCUSSION BY
GEORGE W. TILLSON, WALTER G. ELIOT, CHARLES A. SULLIVAN, RICHARD A. BERRY, MAX L. BLUM, HENRY I. LURYE, GEORGE S. RICE AND THE AUTHOR.

It is not my intention to describe any particular piece of work, but to call to your attention, as simply and clearly as I can, the general conditions and principles involved in the construction of subaqueous tunnels by means of shields with the aid of compressed air.

The operation includes all of the ordinary problems of other tunnel work—administration, supply of materials and tools, transportation and proper direction and management of labor. In addition, there is required for compressed-air work a large mechanical plant, and the work is prosecuted under the most trying physical conditions.

In my opinion, it is impracticable, if not impossible, to drive a tunnel through treacherous, water-bearing material, such, for instance, as is found beneath the East River, without using a shield. Compressed air, however, is not absolutely necessary. The Thames River Tunnel, in which the first shield was used, was constructed without the aid of compressed air.

*Engineer of the New York and Long Island Railroad Company.

It was not until 1879, in the Hudson River Tunnel, now nearing completion, that compressed air was applied to tunnel construction. Since then experience with compressed air has been so extensive and satisfactory, that he would be rash indeed who would attempt to drive a subaqueous tunnel through dangerous material without the help of both a shield and compressed air.

The shield, as its name implies, is used for protection, to prevent the falling of the roof and also to hold the face and bottom when this becomes necessary. It should be carefully designed to suit the conditions and requirements of the work on which it is to be used. For running or loose material the shield is generally a steel cylinder with a diaphragm in the forward part. In front of the diaphragm the cylindrical shell extends a sufficient distance to form or to have attached thereto a cutting edge, and to hold the roof for at least the distance of a "shove." Behind the diaphragm, the cylindrical shell or "tail" extends such a distance that when the shield is shoved forward it may still envelop the tunnel lining and form a complete protection during the erection of a ring or section of masonry. The diaphragm should be proportioned to withstand the total pressure over the whole face of the tunnel, with the air in the tunnel at normal atmospheric pressure.

Transverse and vertical girders attached to the shell of the shield form the frame of the diaphragm. Between the girders there are pockets through which men may get to the face of the excavation. On these pockets there are doors or shutters of suitable design which may be quickly closed so as to prevent an inrush of material in case of a "run."

I would remark, in passing, that the shutters appearing on the shield down in Plate XLV have not proven satisfactory. They cannot be handled quickly enough, and in case of a run a man might be overwhelmed before he could get the last of the shutters in place.

Within the diaphragm near the shell of the shield are placed the hydraulic jacks, for forcing the shield forward, working against the tunnel lining which has been put in place. On the face of the diaphragm are placed the valves for working the jacks, the valves being connected with the jacks by flexible copper pipe.

FIG. 1.—FRONT VIEW OF SHIELD AFTER FINISHING ITS WORK.

FIG. 2.—BULKHEAD, SHOWING AIR-LOCKS.

Fig. 1.—Shield Completed and Ready for Work.

Fig. 2.—Shield in Process of Erection.

FIG. 1.—CAST-IRON LINING.

FIG. 2.—FINISHED TUNNEL, N. Y. & L. I. R. R.
FIRST PASSENGER CAR TO PASS UNDER EAST RIVER.

For working in clay or material which will "stand," and where it is only necessary to support the material overhead, a "roof" shield is sufficient. The shield used on the East Boston Tunnel is an excellent example of this type. On this work the side walls were constructed in drifts, excavated and timbered ahead of the shield. The side walls supported the shield as it was shoved forward by hydraulic jacks attached to the shield. Within the shield were also located the pumps for working the jacks.

To avoid the necessity of waiting for the concrete to set after building a section of the arch before another shove could be made, the jacks worked against steel rods built into the concrete, and abutting against rods previously built in. The movement or "shove" of this shield was 2 ft. 6 in. In the material encountered on this work it was quite easy to drive the small side drifts, and the side walls, being built carefully to line and grade, served admirably to carry the shield used to support the roofs of this large excavation during construction.

Brunell's description of a shield in his original patent embodies all the essential features of the modern machine, and to him is due the credit of the conception of this method of tunnelling. To Greathead, however, is generally conceded the credit for its development and first economically successful application. The shield used by Brunell in the construction of the Thames River Tunnel was rectangular in shape, and was composed of twelve sections, each being shoved forward independently of the others. At the front of each section were breasting boards, held in place by screw jacks. Each breasting board was worked out carefully 6 in., until all the breasting boards in one frame had been so advanced, when the frame itself was pushed forward. When all the frames had been advanced, 6 in. of the brick lining was built. Then the breasting boards and frames were again advanced, another section of lining built, and so on until the completion of the work. This tunnel was twenty years in building, from 1823 to 1843, and when we consider the magnitude and difficulties of the undertaking with the meager mechanical facilities of that time at the command of those directing the work, it must be ranked as one of the great achievements of modern times.

Turning now to Plate XLVIII, you will see a sketch showing a

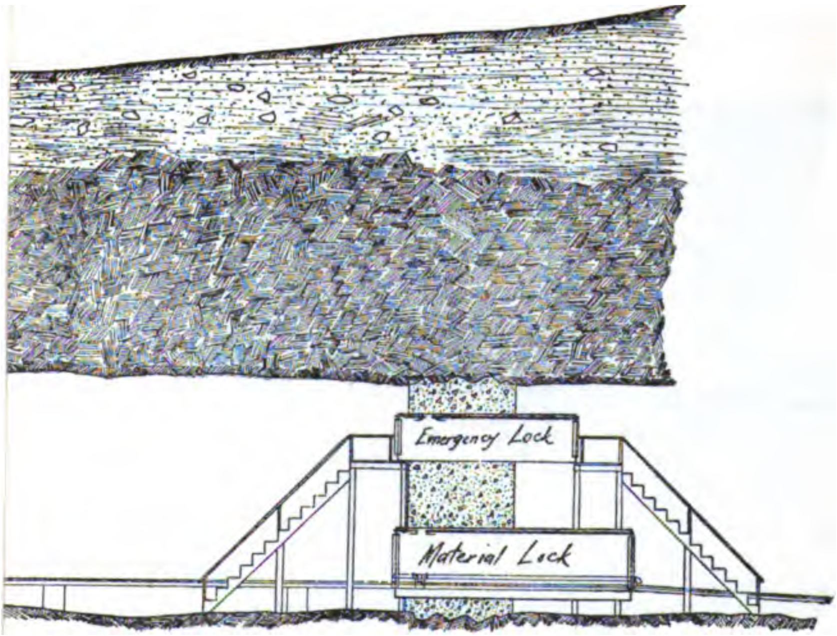
section through a tunnel being driven with a shield and compressed air, and being built with cast-iron plates.

This iron lining is made in rings cast in segments and suitably ribbed with flanges. Great care should be taken to see that these plates are in perfect contact and tightly bolted together as the work proceeds. Open joints are a constant source of trouble, causing loss of air and leakage of water. The plates are handled by means of an erector, shown in the cut just behind the shield. This erector is mounted on a platform and is moved up on rollers as the shield advances. It is an arm revolving about the central axis of the tunnel with a ram working in the arm. A plate is brought to the face, the arm is moved around to the proper position, it is then shoved out and the plate bolted on through a lug provided for this purpose. The arm is then revolved until the plate is in the position it is to take in the ring, the ram is then shoved forward and the plate bolted into place.

On the right is shown a concrete bulkhead in which are built the locks, usually one or two long material locks on the track level, and an emergency lock, which should be placed as high as practicable, so that if the tunnel becomes flooded it may be of use as long as possible. In the bulkhead pipes are also built through which air is pumped into the tunnel, other pipes for blowing water and debris out of the tunnel, and others for passing rails and such long material as will not pass through the material locks, other pipes for telephone and electric wires, etc. This bulkhead should be made as nearly air-tight as possible, and be designed to stand the highest pressures that may possibly be used.

The sketch shows an excavation through rock, the bulkhead being built in rock, and the cast-iron lining commencing where, either because of water or bad rock, it is thought advisable to use an iron lining. At the face is shown rock in the lower part and soft material in the upper part of the face and overhead. This is often the most troublesome condition with which to deal. The rock must be drilled and blasted and the top must be breasted and held securely while the rock excavation is proceeding, which is, of course, a slow, tedious operation, and while the shield is so long standing still the escaping air at the top is agitating the material so that it is continually getting softer and more difficult to hold.

PLATE XLVIII.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
CLARKE ON TUNNELLING
UNDER COMPRESSED AIR.



Bulkhead.

One of the principal difficulties experienced in driving a tunnel using compressed air is the difference in the hydrostatic pressure on the face. This pressure must, of course, vary with the depth, so that the pressure on the face varies from the top to the bottom by an amount or head equal to the height of the tunnel. The air pressure within the tunnel is the same over the whole face, and consequently where the air pressure just balances the hydrostatic pressure at any point there is an excess of air pressure and an escape of air above this point, and an excess of hydrostatic pressure with water running into the tunnel below this point. To get the best air pressure for different conditions requires the exercise of fine judgment with long experience.

In advancing the shield different methods are used to suit the varying materials encountered in the progress of the work. When the material is soft clay, such as is found under the Hudson River, the pockets may be all closed and the shield shoved ahead, displacing or shoving aside the opposing material. When the ground is too stiff to be entirely displaced, the pockets may be partially opened, and the shield then pushed into the face, allowing a portion of the material to "bleed" into the tunnel as the shield advances. With either of these conditions the operations are very simple and rapid progress may be made.

Where the face is so stiff that it will not yield to the pressure of the shield against it, the material must be removed from in front before the shield is advanced or during its advance. This may be done in many different ways. The method generally used is for the men to get out in front of the shield and to excavate to a vertical face about to the cutting edge, and to hold the face with breasting boards braced against the diaphragm of the shield. When the face is securely breasted the shield is shoved forward, the cutting edge or the part of the cylinder in front of the diaphragm only being forced into the face. During the shove the breasting boards are held in place by adjustable braces or guns bearing against the shield itself, the braces being shortened as the shield advances, or by braces running through the shield and bearing against stationary cross-pieces resting on the tunnel lining. After the shove is completed, the jacks are sent back to place, another ring of iron is erected, and then another

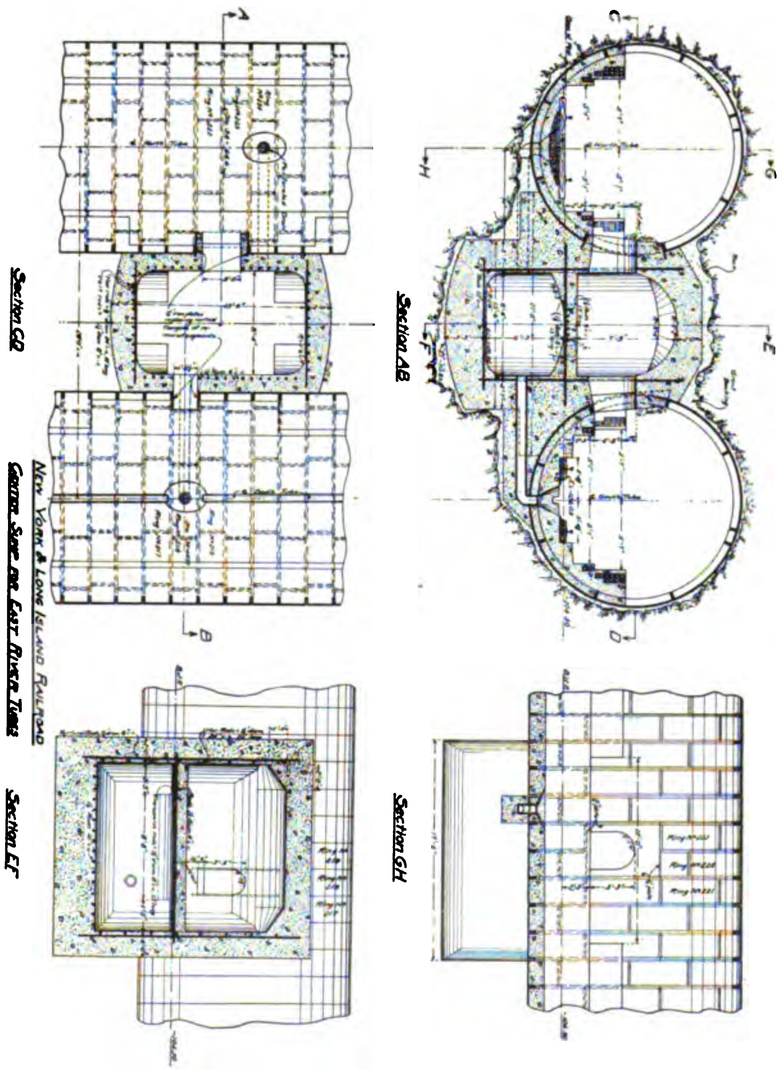
slice of the face is taken off or "breasted down," and we are ready for another shove. When there are boulders ahead they must be removed, sometimes by blasting.

The face is frequently running sand containing so many boulders that the shield cannot be shoved forward until they have been cleared away, especially from in front of the cutting edge. This makes it necessary to breast down and work in front of the shield. When the "cover" or material over the shield is so loose or thin that the air pressure cannot be raised above the hydrostatic pressure at the highest opening of the shield, this running sand face is very dangerous and treacherous, and may only be attacked from one pocket at a time, the pressure being carefully regulated to suit the point at which work is being done, all other pockets being closed. It becomes at times almost impossible to open the doors or shutters sufficiently to get out in front of the shield. This condition is caused by a running, almost liquid "face" and the impossibility, as already explained, of maintaining an equilibrium of pressure over the whole face.

To be able to carry air pressure greater than the hydrostatic pressure at the top of the shield there must be sufficient weight or resistance in the material of the face to sustain the excess air pressure. This may be brought about when necessary either by depositing suitable material over the tunnel or by stiffening up the material of the face by blowing in grout.

Usually the air pressure exceeds the hydrostatic pressure at the top and there is a constant and regular loss of air through the upper part of the face. The loss is replaced and the pressure maintained by the air that is being continually supplied by the compressors. When any spot in the face for any reason becomes too weak to hold the air pressure there is a "blow" or explosion at this point and a greater loss of air. Should this loss be more than the compressors can make up quickly the pressure is reduced. As the air pressure decreases, the conditions of equilibrium at the face are completely changed; water runs in through the hole made by the blow, and there may be a "run" or falling of material, and unless this is checked the face may be lost and the tunnel filled with water. In a long chamber there is a greater volume of air, and a "blow" will last longer than if the volume

PLATE XLIX.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
CLARKE ON TUNNELLING
UNDER COMPRESSED AIR.



of air is smaller, thus giving the workmen more time to stop the blow.

Should there be a fall of material from the roof in front of the shield, leaving a void, the hydrostatic pressure at this higher point is still less than that at the top of the shield, and the difference between the hydrostatic pressure and the air pressure is correspondingly increased. The roof is also weaker at this high point, and a blow may be the consequence, followed by a run.

It is thus seen that a "run" may follow a blow, or that a blow may follow and be caused by a run or fall.

To properly handle and care for the face during excavation in treacherous material requires men of skill and daring, and above all they should be of undoubted courage. To run or even hesitate may sometimes mean the loss of the heading with disastrous results. Among the sand hogs are many heroes, men who risk their own lives, to save their fellow-workmen or the work itself over and over again without expectation of reward of any kind. One cannot work with these men without learning to respect and honor them for these qualities of fearlessness and unselfishness in the face of danger that are almost daily shown, and which become the rule rather than the exception.

In my opinion, the man in charge of a subaqueous tunnel should not only possess these manly elemental virtues, but should be unusually alert and intelligent, and should be sufficiently educated or trained to thoroughly understand the theory of pressures. This means an engineer or a trained mechanic. If I may be allowed to say so, it seems to me that our contractors do not always have men in actual charge that measure up to these requirements. The "walking boss," while being a hustler and a man of experience and courage, is often ignorant of the general theoretical principles of his work. One of the best men of his class that I know of was talking to me recently, and among other things said that he liked to have the bulkheads close up to the face, because then he got his pressure more direct and quicker.

I tried to explain to him that with a larger volume of air there is more reserve, and that a certain loss of air would be proportionately less to a large volume than to a smaller volume, and that therefore there would be less loss of pressure, and generally

less variation of pressure during the progress of the work. He was utterly unable to comprehend why this should be, or at least I was unable to explain it to him.

To check "runs" and hold the air in the tube after a blow a bird-trap shield has been used. This is said to have given good service.

The upper part of the diaphragm is closed with plates on the front, and from the bottom up just above the middle of the shield and behind the diaphragm is built a solid partition. Should there be a run the lower part of the shield fills with water, and the plates on the upper part of the diaphragm reach down into the water sufficiently to form an air seal. This prevents the escape of air through the hole made by the blow, and the compressors more quickly recover the pressure. The disadvantages of this shield are that the men in front would find it more difficult to escape in case of a fall, and that it is more difficult to get out the muck from the face.

In Plate XLVI is seen a shield in course of erection. Rollers are set under the shell and lewises are let into the rock at one side of the center line. The shell is erected on the rollers and revolved so as to receive the different sections which are all handled from the lewises in the one position. The riveting is also all done on the ground, the shield being revolved so that all holes may be reached from the one position.

It will be noticed that the shield must envelop the finished section of the tunnel, and that as the shield is moved forward a void will be left around the tunnel corresponding to the difference in size between the tunnel section and the outside dimensions of the shield. This difference must be at least 2 in. in the diameter and is generally more. The void left around a tunnel 16 ft. in diameter must be at least 4 cu. ft. per foot of tunnel. In running ground this void will be filled as the shield moves forward, and there must be a consequent settlement of the ground above the tunnel. No way has yet been devised of filling this void as the shield moves ahead before the ground itself settles into the space left by the shield. Settlements overhead have always taken place, and I believe they always will occur with this method of tunnelling.

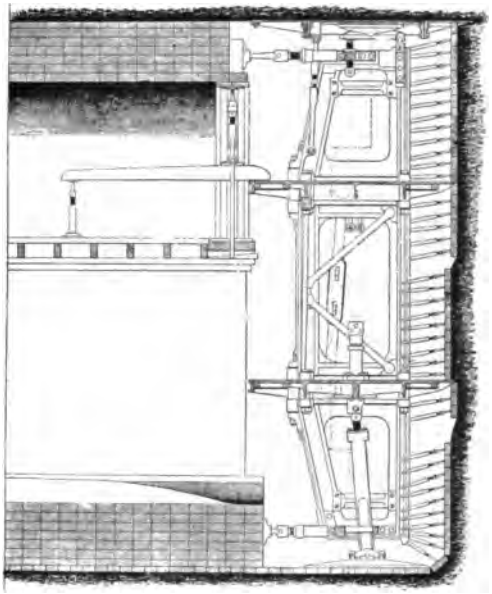


FIG. 1.—BRUNELL'S THAMES TUNNEL SHIELD.
FIRST SHIELD USED.

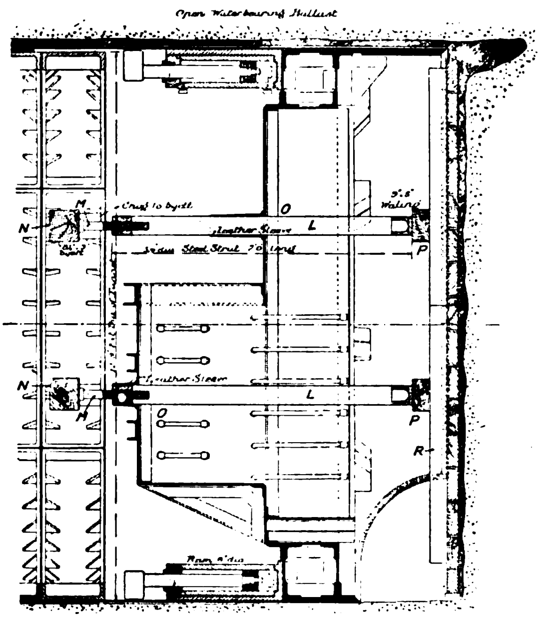


FIG. 2.—BAKER STREET AND WATERLOO RAILWAY SHIELD,
READY TO SHAVE. WATER-TRAP.

PLATE LI.
THE MUNICIPAL ENGINEERS
OF THE CITY OF NEW YORK.
CLARKE ON TUNNELLING
UNDER COMPRESSED AIR.

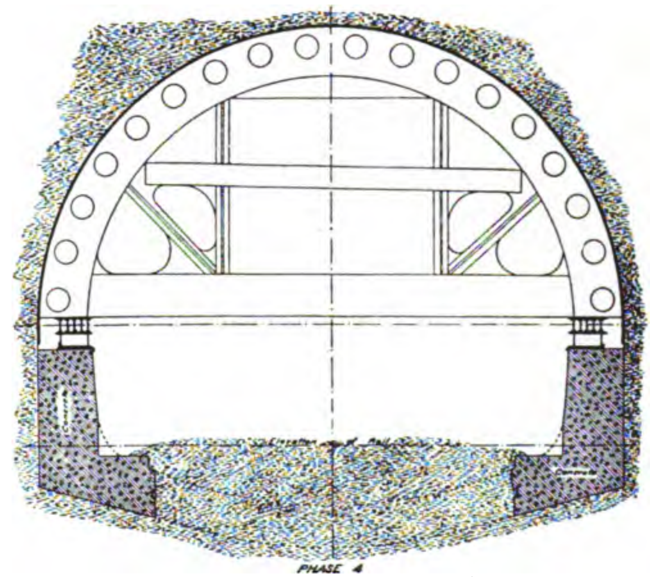


FIG. 1.—SIDE WALLS AND SHIELD FOR EAST BOSTON TUNNEL.

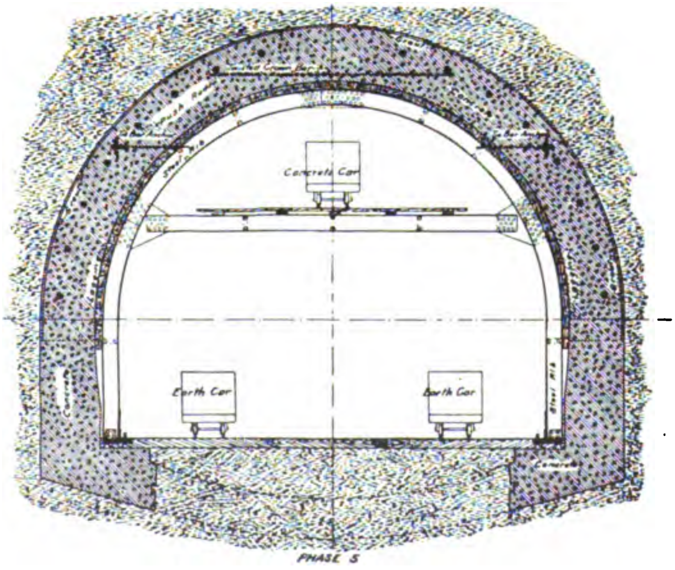
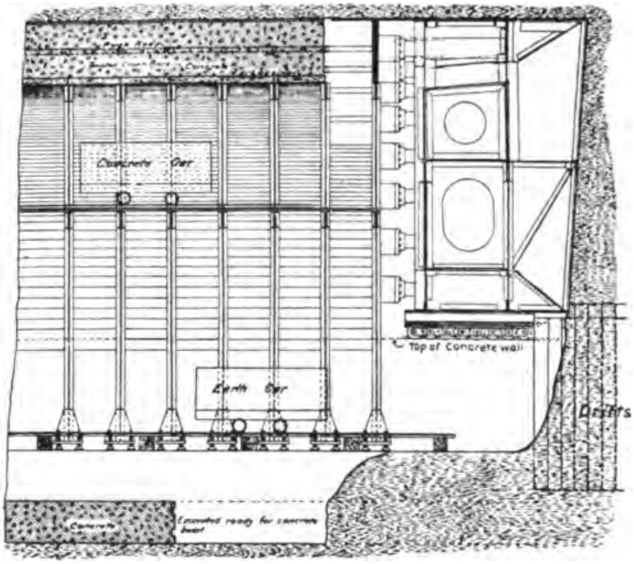


FIG. 2.—EAST BOSTON TUNNEL.



LONGITUDINAL SECTION AT SHIELD

FIG. 1.—SECTION OF SHIELD FOR EAST BOSTON TUNNEL.

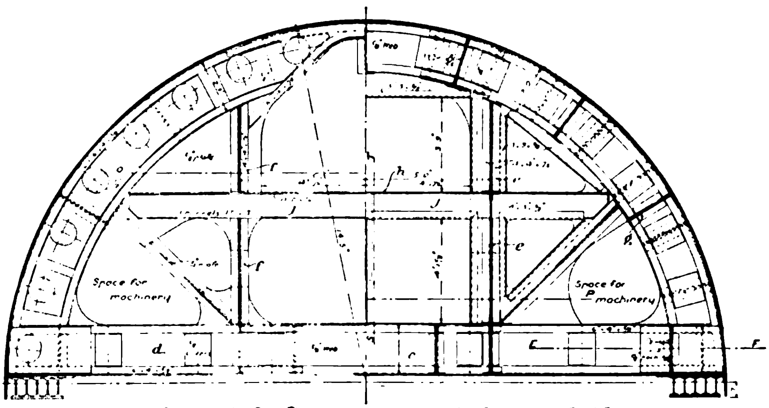


FIG. 2.—SHIELD FOR EAST BOSTON TUNNEL.

In conclusion, I would speak of the necessity of co-operation on the part of all engaged on a piece of work of this character.

As the work progresses it should be done correctly and acceptably. It is not enough for the contractor on his part to say that if it is not right he will make it right, nor for the engineer to come around after the work is done and accept or reject. It is often impracticable to change the finished work, and the consequences are much too serious for any carelessness or neglect to be allowed. Great additional cost and long vexatious delays affecting both the contractor and owner must result from defective work of any kind. A spirit of co-operation should be cultivated and insisted upon, with the good of the work as the only consideration of all engaged upon it. The first evidence of trickery or deception should be stamped out immediately. And if anyone on the work shows such a disposition, be he contractor or engineer, he should be gotten rid of as soon as possible or the work will inevitably suffer.

DISCUSSION.

Mr. Geo. W. Tillson.—The question is now open for discussion. It is a very interesting subject and something upon which a great many people here must have had some experience, especially within the last few years, and we would be very glad to hear from anyone.

Mr. Walter G. Eliot.—May I ask what method is used for caulking the joints?

Mr. Clarke.—The joints are generally caulked with lead or iron filings; in some English tunnels they were filled with wood.

Mr. Eliot.—When you showed us the openings of the shield you stated that there are slots provided for adjusting gates in case of inflow. What purpose do they serve if they cannot be instantly adjusted?

Mr. Clarke.—I mentioned that as a matter of information; the face of a shield is subject to very severe usage. Those frames are more or less bent and twisted and those little shutters which a man picks up and puts in place get jammed and they do not go down. Of course, they are carried generally right along on the shield or on the erector platform, but they do not work satisfactorily. The objection to the door is that if you close a door in the case of a run a man might be on the other side of it. That has happened in work to my knowledge.

The jacks are generally worked on a pressure of from 3 000 to 6 000 lb. per sq. in.

Mr. C. A. Sullivan.—In the event of striking rock what method is used to protect a shield from injury by blasting?

Mr. Clarke.—We have to take chances. We blast as lightly as we can and sometimes the whole face is covered before the blast is set off. That is a very ticklish operation in a shield partly in rock and partly in sand.

Mr. Berry.—I would like to ask how you take the shields out when they meet. Do you take them out?

Mr. Clarke.—The diaphragm is taken out and all the working parts; but the outer cylinder is left in place.

Mr. Berry.—Is it a riveted cylinder about 12 ft. long, which is left in place?

Mr. Clarke.—Yes.

Mr. Blum.—What method is used to get the alignment in a tunnel, that is, the best method for a long tunnel?

Mr. Clarke.—Well, that is another story. The line, of course, is run as in any other tunnel. The line is dropped down the shaft by means of plumb-bobs and generally established thoroughly be-

fore going into the locks; then it is sometimes passed beyond the locks before the bulkhead is put in. We pass lines through the emergency lock; that is about 16 ft. long; the outside door is open, of course, and points are established in that lock; then the outside door is closed and men go on the inside and from those two points project the line into the tunnel. This operation being repeated over and over again.

MR. LURYE.—What is the method of obtaining 5 000 or 3 000 lb. pressure for the jacks? What power do they use? They cannot very conveniently use air.

MR. CLARKE.—They can use air or any other medium which gives a difference of pressure. On some of my work we have electrically-driven pumps at one place and steam-driven pumps at another, which will raise the pressure to 6 000 lb.

MR. LURYE.—Are the pumps outside of the chamber?

MR. CLARKE.—Outside on the surface.

MR. M. H. LEWIS.—I would like to ask what is the best and quickest method of handling a blow-out from the surface?

MR. CLARKE.—It takes a pretty nervy man to go near a blow, but they shove their coats at it, a bag or bale of hay or anything of that kind; anything that will clog and stop the rush of air long enough to allow the material above to fall back in place and choke up the hole or drift.

MR. RICE.—The last question was one of great interest, and if the number of heroic deeds performed in the course of the sandhogs' work were known we would have much more respect for them. Many a time they put their legs or arms into an opening to stop a blow-out.

About a year and a half ago a man was endeavoring to stop one of these blow-outs in the Joralemon Street tunnel. Suddenly he found himself projected through 8 ft. of earth and about 15 ft. of water. He certainly experienced a change of pressure.

The City of New York, through its public works, has done much toward the advance of tunnelling. In 1887, the tunnel for the aqueduct was constructed under the Harlem River. The engineers were then confronted by a problem similar to that of the Board of Water Supply at its Storm King crossing to-day. It was desired to carry the aqueduct in tunnel below the river. Two shafts were sunk upon each side of the Harlem River at a distance of 150 ft. from each other. After they had tunnelled for a considerable distance they realized that there might be considerable danger in continuing the tunnel, so they put in diamond drills and found that there was a crevice in the middle of the river. They, therefore, went to a lower level, about 400 ft. below the surface of the Harlem River, where they would have a complete rock

base or rock tunnel. Diamond drill observations showed that they had struck a perfect contact between limestone and gneiss rock. They found that in some portions of the rock the limestone and the gneiss were frozen together. The sides of the tunnel were perfectly dry because of the great pressure at that depth. If the engineers at that time had had the advantage of compressed air processes, they could have continued in the first drift with a working pressure of 15 to 20 lb., thus bringing about a very great economy in the cost of construction.

The alignment in the East River tunnel, which Mr. Noble has just carried through, was almost perfect. When the two headings were within 65 ft. of each other, being then in sand and gravel, they determined to check up on their alignment and grade. They pushed a 6-in. diameter pipe through from one drift to the other by means of a water jet; this pipe was put in so perfectly that they could get their level alignment through it. The grades varied a little less than .01 ft., the alignment about .13 ft.

The getting of alignment is to my mind merely a matter of patience and perseverance, though many obstacles are encountered. Many tunnels have been run without the use of air, though this necessitates an enormous pumping capacity, and in most instances entails a greater expense.

I think the time is coming when the settlement occasioned by the use of the shield can be avoided. Grout can be used, but this generally clogs all the working parts of the shield.

MR. BERRY.—I would like to ask Mr. Clarke if they give full pressure in the one lock, or transfer from one lock to another. In case a man goes down to 40 lb. pressure, at first the atmosphere gives him about 30, and if he has to take 40 or 45 or 60 lb. do you give it to him in the same lock, or transfer him to another lock?

MR. CLARKE.—That depends on the length of the tunnel and other considerations. In some of the tunnels there are two chambers in which different pressures are carried, but in other places they take it all in one chamber.

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.

ADDRESS

OF

MR. GEORGE W. TILLSON, PRESIDENT OF THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK, PRESENTED AT THE ANNUAL MEETING OF THE SOCIETY, JANUARY 23D, 1907.

According to our Constitution, it is incumbent upon the outgoing President to deliver an address in which he shall briefly detail the work of the Society during the past year, as well as to summarize what work of construction has been accomplished thoughout the entire city. This idea, if continued, will enable future searchers to ascertain from our files the dates of the commencement and completion of important engineering works of the present, as well as to know the early history of this Society, which is destined to be a power in local engineering circles in the not far distant future.

A glance over the past year will show that the Society has been industrious as well as prosperous. It has held all its regular meetings, at which formal technical papers have been read, before audiences that have been continually on the increase. It has held six excursions to engineering works both in and around the city. These trips have been largely attended, and have served to add to the engineering knowledge, as well as to increase the acquaintance and good fellowship of the members, and to my mind this last is nearly as important as the former.

The annual dinner held two weeks ago was a social event in the history of the Society that is without a parallel. Nearly 300 members and guests were present, the largest number of this Society that was ever gathered together. Among the guests were two Borough Presidents, the Comptroller of the City, a Commissioner of Public Works, and other friends of the Society, who had acted as hosts on the different excursions of the year.

In the Constitution of the Society it is provided that a medal shall be given each year to the author of the paper that is considered by a special prize committee to be the most meritorious of the year. After some delay a design for a medal was adopted, and the two prizes that had been awarded up to that date were presented at the January meeting, as well as two beautiful badges to the two Past-Presidents.

The Special Committee on Repairs to Asphalt Pavements made its report in time to have the same published in the 1905 *Proceedings.*

MEMBERSHIP.

On January 1st, 1906, the membership of the Society was 366. During the year 84 new members were elected; but there were also losses during the same time from resignations, death, etc., amounting to 24, so that the roll of the Society on January 1st, 1907, numbered 426, a gain for the 12 months of 60, or almost 17%. This seems and is encouraging, but when it is remembered that there are more than as many more outside of the Society who are eligible for admission, and who must admit the advantages of membership when they know the work that is being done, a still greater increase can confidently be expected in the future.

FINANCES.

The financial condition of the Society is excellent. On January 1st, 1906, the cash balance in bank and in the hands of the Secretary was $1,546.76, with liabilities amounting to $203, and the trial balance of the Secretary showed a balance of $2,320 in favor of the Society. On January 1st, 1907, the cash balance had increased to $2,584.01, with $131.52 liabilities. The Secretary's report on the same date showed a balance of $3,606.06.

During the year the current receipts were $5,380.88, and the disbursements $4,343.63, leaving a net gain of $1,037.25. Two causes tended to bring about this result; first, the increase in membership previously alluded to, and second the fact that a change was made in the Society rooms, by which quite a saving in rental was made.

But perhaps the most important change of the year was the consummation of arrangements that have resulted in our being permanently housed in this magnificent building, with all the privi-

leges, conveniences, and prestige that go with its occupancy. Without doubt the most serious problem that faced the Society after it got fairly upon its feet was the question of a permanent home. To house any Society of moderate means in New York City is a work of no small proportions; and while our previous arrangements have been very satisfactory up to the present time, your Board of Directors has felt that if the Society was to continue and perform its work to the utmost, permanent quarters of some kind must be acquired. Had this building not been completed just when it was, the settlement of this question would have been very difficult. The past administration can consider itself very fortunate that circumstances brought about the solution thereof.

But I want you to feel that the other accomplishments of the year have been reached only by the hard and earnest work of the Committees of the Board of Directors. Some have, perhaps, seemed to do more than others, but all have been imbued with the spirit of working for the best interest of the Municipal Engineers.

Ten years ago, in making some remarks before the Brooklyn Engineers' Club, your President ventured the prediction that in the next few years to come there would be more engineering work in Greater New York than on any other equal area in the world. This was, you must remember, when the Williamsburg Bridge was in embryo, and the subway only hoped for.

When the year's construction work of this city is considered, as a whole, its magnitude is appalling. The enterprises completed, begun, and contemplated, mount up not simply to millions but hundreds of millions. A very brief summary only can be given.

BOARD OF WATER SUPPLY.

On November 3d, 1905, the city's petition to the State Water Supply Commission was presented, as required by the law. Eight public hearings were held by the State Commission, extending from November 27th, 1905, to February 20th, 1906, and the general approval of the plans was made on May 18th, 1906. This approval left the way clear for the Board to vigorously push the preliminary work of the location of the reservoir and aqueduct line necessary before the actual commencement of physical work. Very much has been accomplished, as is shown by the following statement:

Reservoirs.

The location of the most favorable dam sites for the Ashokan reservoir has been fully determined, and the most economical capacity, and the elevation of the full reservoir lines have been definitely fixed.

Topographical surveys of the entire reservoir basin of about 16 000 acres have been made, and maps for the same are in an advanced stage of preparation. The land surveys necessary for the condemnation of the entire area have been completed, and the maps necessary for the formal condemnation proceedings are partially prepared.

Many studies of designs of the main and auxiliary dams have been made, and it is believed that the completed design can be prepared within the next 3 or 4 months.

Some preliminary surveys have been made in the Rondout and Schoharie water-sheds.

On the aqueduct line the surveys of the land necessary for Kensico and Hill View reservoirs have been completed. The maps for the condemnation of this property are in an advanced state of preparation.

A filter site has been selected.

The Aqueduct Line.

Of the total length of Hill View reservoir, 86 miles (40%) has been finally located, of which about 13 miles, or 15%, has been prepared for contract and will be let as soon as the legal proceedings for the acquirement of the land can be completed. In order to accomplish this result, it has been necessary to make 550 miles of surveys and 12 miles of sub-surface borings.

Headquarters.

The work of creating and maintaining the very large working force necessary for this work has devolved on the Headquarters Department. To this end the Municipal Civil Service Commission has examined thousands of applicants and thousands of men have been interviewed in selecting the force actually appointed.

A comprehensive plan of organization has been adopted, and the preliminary studies for the design of many important struc-

tures have been made, as well as the contract plans and specifications of 13 miles of aqueduct lines.

In general, it may be said that many of the most important and fundamental problems have already been determined, and it is confidently believed that no great piece of public work undertaken in the past can show so much and so high a quality of work accomplished during the same length of time.

BOARD OF RAPID TRANSIT RAILROAD COMMISSIONERS.

Work on the Manhattan-Bronx Subway Railroad, known as Contract No. 1, has been in progress north of the Harlem Ship Canal on the west side branch as remains uncompleted. The portion from One Hundred and Fifty-seventh Street to the Canal was completed and put in operation early in the year. At the present rate of progress it will be in operation by February 1st, 1907. Work on the extension of the west side viaduct was taken in hand the latter part of the year and is being vigorously prosecuted, and will be in operation next summer. At the close of the year 22 miles of railway were in operation. The traffic has increased with remarkable regularity, said traffic amounting at times to nearly 600 000 passengers per day.

The question of fire hazards in the subway, with particular reference to car construction, was the subject of study and investigation during the year, with the idea of eliminating as far as practicable any deficiencies that might be found in the equipment as a whole.

Work on the tunnels under the East River, and also on the remaining uncompleted portions of the Brooklyn-Manhattan Railroad in Brooklyn along Fulton Street and Flatbush Avenue, has been diligently prosecuted.

On Monday, December 17th, 1906, the hoods of the two shields of the North Brooklyn tube met with no apparent variation horizontally and vertically. Previous to the meeting of the shields, when between 60 and 70 ft. apart, a test tube was forced from one heading to the other, and the variation in grade and alignment was obtained, amounting in grade to less than $\frac{1}{100}$, while the alignment varied about $\frac{13}{100}$ ft.

The two tunnels are expected to be in operation some time in April. During the year surveys have been made for new routes

adopted by the Board in May, 1905. The length of these routes is 165 miles, and their estimated cost $300 000 000. Contracts for two of these schemes have been authorized. One is the Lexington Avenue route, which extends from the Battery to the Southern Boulevard in the Bronx. Another beginning also at the Battery, running up the west side *via* Seventh, Eighth and Jerome Avenues to Woodlawn.

The tri-borough route is also ready for contract. This starts at Pelham Bay Park, running south on the east side, crossing to Brooklyn on the Manhattan Bridge, thence to Coney Island.

The question of ventilation and cooling the subway air during the warm weather has received serious consideration, and the following plans have been adopted:

Cutting openings in the vault lights from the Brooklyn Bridge to the Ninety-sixth Street station, inclusive, and installing gratings therein, in order to provide more inlet openings at stations. About 5 000 sq. ft. of vault lights were cut out and gratings installed, thereby providing 2 500 sq. ft. additional effective opening at stations for the inlet of air.

Installing louvres in the outlet openings now existing in the Park between Columbus Circle and Ninety-sixth Street stations to insure the outflow of air from the subway at these points.

Louvres were also installed between the Columbus Circle and Sixty-sixth Street stations, and for the openings at Sixty-sixth and Ninety-sixth Street stations.

Installing an experimental cooling plant at the Brooklyn Bridge station, consisting of driven wells supplying cold ground water, pumps distributing the water through cooling coils, and fans blowing air over the coils and through distributing ducts directly over the station platforms.

At midnight of August 29th, or after 14 hours' operation, the average temperature in the station had been lowered 7°, down to 75° fahr., the same temperature as the outside air.

The plant was operated on week days from 7 A. M. to 8 P. M., and on Sundays from 10 A. M. to 8 P. M. This lowered the average of the temperature during the operating hours about 4 or 5 degrees, bringing the temperature of the station down to within 1 or 2 degrees of the outside air.

The air, as it is discharged from the ducts directly over the platforms, was noted to be from 3 to 6 degrees cooler than the average temperature in the station. Passengers therefore obtained the immediate benefit of this additional cooling before it was diffused throughout the station. Because of this the plant was only operated during the daytime. It may be necessary to operate it continuously for 24 hr. in very warm weather.

DOCKS AND FERRIES.

Docks.

On the lower section of the East River in Manhattan about 1 000 ft. of bulkhead wall has been built. Eleven new piers have been completed. Near Fulton Street a 3-story steel and concrete building has been constructed for handling and marketing fish.

On the Blackwell and Yorkville sections, between Sixty-fourth and Eighty-first Streets, East River, a new marginal street about 1 mile long has been built, partly under the Commissioner of Docks and partly under the Borough President, and a bulkhead wall is being constructed along the river front.

On the North River in the Chelsea section between Bloomfield and West Twenty-second Streets, the bulkhead and 9 piers have been finished. These piers represent the highest type of pier building ever attempted in this country, and plans are being prepared for covering them with double-deck steel sheds, with reinforced concrete decks in the second story. It is also proposed to build a marginal street in front of these piers 3 000 ft. long, with a paved roadway 250 ft. wide.

Bulkhead walls are also being built near Rector Street, and One Hundred and Thirty-fifth Street, North River.

Ferries.

The two terminals at Whitehall Street and St. George have been completed. Three new ferry contracts have been entered into, one at the easterly end of the Whitehall terminal for Thirty-ninth Street, Brooklyn; one at Thirty-ninth Street, Brooklyn, and one at Stapleton, Staten Island. At Stapleton work has been begun on platforms, racks, bridges, etc., for a new ferry, and also upon a new pier, 1 200 ft. long and 60 ft. wide, with reinforced cement

deck. At Thirty-ninth Street work is under way for a new ferry terminal.

Contracts for three new ferry-boats have been let for the South Brooklyn service and the boats are now being built.

SURVEYS, ETC.

The Department has continued its surveys of Jamaica Bay, as this bay is entirely under the charge of this Department.

At North Brother's Island a rip-rap embankment and concrete sea wall 1 874 ft. long are being built.

At Riker's Island work is in progress on a rubble stone wall 1¾ miles long on the embankment built last year.

On Newtown Creek, Brooklyn, proceedings have been instituted to acquire the necessary property to construct 1 000 ft. of bulkhead and two piers 1 400 ft. long and 60 ft. wide. Plans for the wall and one pier have already been prepared.

Briefly speaking, the work of the Dock Department has added to the city 16 000 ft. of new wharfage room, 559 000 sq. ft. to the area of city piers, 2 100 lin. ft. of bulkhead wall, and 12 piers and 2 platforms.

BROOKLYN GRADE CROSSING COMMISSION.

The object of this Commission is to abolish all grade crossings on the Brighton Beach Railroad to Coney Island, and on the Long Island Railroad between Bay Ridge and the Borough Line. On the Brighton Beach improvement 7 500 ft. of concrete retaining wall has been completed and 125 000 cu. yd. of earth excavated between Church Avenue and the Long Island Railroad crossing, and trains are being operated on one track in the cut. Between the Long Island Railroad crossing and the Neptune Avenue bridge, abutments of concrete have been built at 15 different streets and 233 000 cu. yd. of material have been placed in the embankment.

On the Bay Ridge improvement 496 000 cu. yd. of earth have been excavated, and 16 000 cu. yd. of masonry put in place. 10 876 lin. ft. of track have been laid at different places. The highway bridges over the depressed tracks of the railroad at Gravesend Avenue and at East Third Street have been completed and put in ser-

vice, while the bridge at New Utrecht Avenue lacks only the east sidewalk of final completion.

BOARD OF ESTIMATE AND APPORTIONMENT.

This Board during the past year has authorized assessable improvements as follows:

Borough.	Number.	Estimated cost.
Manhattan	83	$1 028 700
Brooklyn	240	2 633 150
Bronx	146	3 754 600
Queens	78	1 383 150
Richmond	18	1 000 300
		$9 799 900

The Board has also either committed itself to or specifically authorized improvements for bridge terminals, bridge contracts, relief sewers, hospital ferries, filtration plants, etc., not including rapid transit work, the estimated cost of which is $55 000 000.

BRIDGE DEPARTMENT.

Brooklyn Bridge.

Changes in the Manhattan terminal and the number of cars making up trains have increased the capacity of the bridge 9 000 per hour. On December 13th, 1906, 402 705 people crossed the bridge, 212 651 going to Manhattan and 190 054 to Brooklyn.

The surface car tracks were relaid in October with a new type of construction, which it is believed will obviate delays heretofore experienced when repairs were being made. Additional stairways have also been built.

Williamsburg Bridge.

New trolley car stands were added to the Manhattan end early in the summer, permitting the operation of 2 366 cars over the bridge instead of 1 994 as formerly.

A sub-surface station to accommodate all the railway traffic, except that of the New York City Railway Company, was contracted for in June, 1906, and is now about 20% completed.

The people crossing the bridge on December 13th, 1906, was to Manhattan 78 335, to Brooklyn 79 404.

This bridge is now entirely lighted by electricity generated in the bridge lighting station, the fuel being supplied by the Department of Street Cleaning in the form of street refuse.

MANHATTAN BRIDGE.

Work on the anchorages has continued through the year, that on the Manhattan being about 50, and on the Brooklyn end about 60% completed. The contract for towers, cables, and superstructures was entered into in June, 1906. Steel has been delivered under this contract since October 15th. Plans for the approaches have been made and approved by the Art Commission, and contracts for them will soon be let.

BLACKWELL'S ISLAND BRIDGE.

Work on this structure has been delayed by strikes, but since April 19th, 13 500 tons of steel have been put in place. The erection of the river spans has been begun and is progressing well. The masonry construction is proceeding as rapidly as conditions will allow. The plans for the viaduct approach have been approved by the Art Commission and bids received for constructing the same.

BOROUGH BRIDGES.

The new bridge over the Harlem Ship Canal at Broadway is practically completed and has been in use since June. The Southern Boulevard approach to the Willis Avenue Bridge was finished early in the season and the bridge over Flushing Creek in Queens was opened to travel on October 17th.

Work is in progress upon the University Heights Bridge over the Harlem River, on the Pelham Bridge in the Bronx, and on a new bridge over Dutch Kills at Borden Avenue; also upon a temporary bridge over the Harlem at Madison Avenue where a new permanent structure is to be built.

Borings have been made for the Henry Hudson Memorial Bridge. New bridges have been proposed over the Hutchinson River at the crossing of the Boston Post Road, one to replace the present Union-

port structure, and new constructions at Strong's Causeway Bridge and at the Little Neck Bridge.

AQUEDUCT COMMISSION.

At the new Croton Dam the last stone was laid January 17th, 1906. This work had been some 13 years in constructing and is the highest masonry dam in existence and is capable of storing some 32 000 000 000 gal. of water. The gates were closed in November, 1905, since which time no water has been allowed to waste from the Croton water-shed.

The west basin of the Jerome Park Reservoir has also been practically completed during the year and the City has had the use of the same.

Work on the Cross River Dam has been prosecuted with great vigor during the season. Sixty per cent. of the masonry has been laid, and highways have been constructed and the reservoir basin cleared to a very great extent. This reservoir when completed will add about 9 000 000 000 gal. capacity to the storage on the Croton water-shed.

The contract for building the Croton Falls Reservoir was let on August 23d, 1906. A great deal of progress has been made in assembling the necessary plant, including steam shovels, narrow-gauge railway, engines and equipment, buildings for laborers' camps, etc. A very considerable amount of excavation and other work preparatory to actual construction next season has been done. This reservoir when completed will add about 14 000 000 000 gal. to the storage on the Croton water-shed.

DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY.

Borough of Brooklyn.

During the past year the work of construction covered several driven well stations, two infiltration galleries, a 72-in. steel force main, 36 miles of distribution mains, including over 1 100 hydrants and about 1 500 gates, and 16 miles of high-pressure fire-service mains. The cost of construction work during the year was about $2 000 000.

PUBLIC BUILDINGS AND OFFICES.

BROOKLYN.

Contract awarded for one public bath, and plans and specifications are in preparation for two more, as well as for a new Municipal Court House.

The construction of a new public market, located on the East River between Thirty-sixth and Thirty-eighth Streets, was authorized by the Board of Estimate and Apportionment in April, 1906, and a sum of $200 000 appropriated for the preparation of the land.

The plans for the market proper have been prepared in the office of the Bureau of Public Buildings and Offices, and it is expected that active work will begin in the early spring. The estimated cost of the entire project is a little more than $2 000 000.

MANHATTAN.

Between East Twenty-third and East Twenty-fourth Streets, at Avenue A, there is being constructed a public bath 165 ft. front and 140 ft. deep, the largest in the city. Its estimated cost is nearly $250 000. Money has been appropriated, sites selected and plans made for four additional baths. Their construction will vary greatly from those already built as they will be 3 stories high, and contain gymnasiums, playgrounds, and roof gardens.

BOROUGH PRESIDENT'S DEPARTMENTS.

PAVEMENTS.

Miles of pavements laid during 1906.

	Sheet asphalt.	Block asphalt.	Granite.	Medina.	Wood.	Macadam.	Belgian.	Iron slag.	Brick.	Total.
Manhattan	8.15	7.82	2.65	......	4.19	......	0.05	......	......	22.86
Brooklyn	36.41	4.70	4.48	1.72	......	0.94	......	0.26	......	48.46
Bronx	1.49	8.02	0.20	.28	.13	......	......	......	......	5.12
Queens	0.42	1.20	......	......	......	3.27	......	......	0.82	5.71
Richmond	......	2.51	0.54	......	......	......	......	0.25	......	3.30
	46.47	19.25	7.82	2.00	4.32	4.21	0.05	0.51	0.82	85.45

Sewers.

Miles of sewers laid during 1906.

Manhattan	1.74	miles.
Brooklyn	20.00	"
Bronx	11.10	"
Queens	6.50	"
Richmond	0.78	"
	40.12	miles.

TOPOGRAPHICAL WORK.

Bronx.

The street plans for the territory west of the Bronx River are all filed, covering 12 317.5 acres.

During 1906, three sections, 31, 32 and 33, located east of the Bronx River, defining about 50 miles of streets, were filed. In addition, three more sections, 44, 47 and 49, are before the Board of Estimate and Apportionment.

In addition to these, 59 maps, covering amendments, changes and new work, were prepared in the Topographical Bureau and filed, after having been approved by the Board of Estimate and Apportionment.

The triangulation of the Borough of The Bronx under the direction of the United States Coast and Geodetic Survey was completed during 1906, and considerable field and office work was done to connect and adopt the street system with the established triangulation co-ordinates.

Brooklyn.

The Topographical Bureau during the year laid down on the Ocean Parkway a standard of 150 ft. in length.

This standard was laid down in a modern and scientific manner, under the direction of Mr. Frederick W. Koop, Principal Assistant Engineer on the triangulation of the City of New York, by the United States Coast and Geodetic Survey. The tape used was one of the four New York City base line tapes, made and tested in Washington especially for the triangulation of the City of New York. These tapes were also standardized four times with three

most valuable United States Coast and Geodetic Survey base line tapes that were used to measure nine bases along the 98th meridian, and also used to measure the Ocean Parkway base and the Unionport base, together with the New York City base line tapes.

The high accuracy and reliability of this standard are therefore unquestionable. The technical work was done at 8 P. M., so as to obtain absolutely correct temperature. This was done by lashing two base line thermometers to the tape and supporting it from the ground. The tension used was 15 kilograms, about 35 lb. This standard was later subdivided into a 50-ft. and a 100-ft. standard.

RICHMOND.

Eighteen triangulation towers were built in the early part of the year, varying in height from 15 to 84 ft., and the field work was completed by "The Triangulation of the City of New York" in the fall. Nearly all of the 43 stations have been monumented and connected to traverse lines. As soon as the Coast and Geodetic Survey office finish the results of their computations of the triangulation, it is proposed to base all future work upon the co-ordinates furnished.

The plane table has superseded all other instruments for filling in details in the rural districts and nine are employed in the topographical mapping of the borough. The plane table sheets, 27 in. by 40 in. in size, plotted to a scale of 50 ft. to an inch, are photolithographed and printed to a scale of 150 ft. to an inch on sheets of the above-mentioned size, each covering about 500 acres. On these printed sheets the preliminary plan, showing street lines and grades, is laid out.

In planning the street system, endeavor is made to make full use of existing thoroughfares by widening, and using them when practicable as diagonals in the proposed street system. A park system is being planned along with the streets. Attempt is made to introduce variety into the street layout corresponding to the diversity in topography.

QUEENS.

During the year surveys were made for contouring an area of 10 040 acres, which involved the running of 920 miles of contour lines. These surveys were all accurately mapped.

Final maps were made showing block dimensions and street widths, as adopted by the Board of Estimate and Apportionment on November 13th, 1903, March 13th, 1905, and December 29th, 1905.

A large amount of general surveying for different purposes was done, and a great many maps made for opening, closing, and changing the lines of streets.

Of the 80 000 acres of territory in this borough, of which 10 000 are under water, 54 000 have been surveyed, a street system adopted for 16 000, and 9 000 acres have been mapped. This work has practically all been done during the past 4 years.

SUBSURFACE WORK.

During the latter part of the year 1906 there was established in the office of the Borough President of Brooklyn a bureau to be known as the Division of Substructures, for the purpose of accumulating and mapping all information obtainable relative to substructures in the borough streets.

A careful study has been made of the methods pursued by other cities, namely, Boston and Philadelphia, in accumulating and mapping subsurface data, and it is proposed to adopt, in part, the Philadelphia method, where a bureau of this character has been in existence some years and the information accumulated has been of great value to the municipality.

In Brooklyn it is proposed to prepare substantial reference maps, in sheet form, such finished sheets to be 32 in. by 42 in. and the scale 20 ft. to the inch. By dividing the borough into 20 large divisions, and subdividing the same into small sections, the small sections to be the size of the finished sheets, the work can be carried on in any locality desired.

Field parties are now at work making surveys for layout maps and locating all street openings, such as manholes, electric junction boxes, gas drips, and water gates, also trolley tracks, hydrants, corner basins, vaults, etc., and the data obtained is being plotted in the office.

The location and size of pipes from manhole to manhole, or junction box to junction box, etc., are obtained from the city department having charge of such structures or from the public service

corporation utilizing such conduits, etc. The various city departments doing work in the borough streets furnish the bureau with information relative to all substructures uncovered by them in the course of their work.

The finished sheets will show sizes and locations, by reference to the nearest curb and depth below the surface, of all pipes, conduits, etc., in the borough streets.

REFUSE DISPOSAL.

In Richmond Borough, the Engineer-Superintendent of Street Cleaning has made perhaps the most complete and extensive investigation of refuse disposal on record, involving experimental work covering a period of 2 years, and a series of visits to 40 refuse destructors in Great Britain, which resulted in the adoption of mixed refuse destruction at high temperature, with incidental utilization of power. Bids have been received for the erection of a refuse destructor at West New Brighton, and the outcome of the radical departure from the ordinary method of procedure will be awaited with interest by municipal officials. There is no doubt that the subject of refuse disposal has suffered in the past because of lack of scientific attention.

IMPROVEMENTS BY PUBLIC SERVICE CORPORATIONS.

There are many other improvements being carried out in the city by the different corporations, the most important of which are:

The tunnel railroad under the Hudson River, under and across the Borough of Manhattan, and under the East River, with its extensive terminal in Manhattan. This latter feature involved the acquirement of 28 acres of land in the heart of Manhattan, the demolition of the buildings occupying it, and the excavation of the entire area to an average depth of 50 ft., a large amount of which was solid work.

The construction of the New York and New Jersey Railroad tunnel under the Hudson River to the foot of Morton Street, extending to Eighth Street and Fourth Avenue, and up Sixth Avenue to its terminal between Thirty-second and Thirty-third Streets.

The construction of the Hudson and Manhattan Companies' tunnel from Jersey City to its terminal in Dey Street, and running through Cortlandt Street.

The tunnel work of the Belmont Company under the East River to connect by trolley the Borough of Manhattan with the Borough of Queens. This is nearly completed.

Studies have been made for a subway along Eleventh Avenue and other streets, for the use of the tracks of the New York Central Railroad. Negotiations are now pending for the carrying out of this work.

The above descriptions are only bare outlines of what is being done in our city, and it is only by outlining them briefly that one is able to comprehend their magnitude. The careful consideration of these great works is recommended.

AWARDS OF PRIZE MEDALS.

These papers will be found in *Proceedings* for the years indicated.

1903.

JAMES COPPER BAYLES, M. E., Ph. D., for paper entitled: The Problem of the Maintenance of Asphalt Pavements in Manhattan.

1904.

GEORGE WILLIAM TILLSON, C. E., M. Am. Soc. C. E., for paper entitled: The Maintenance and Repairs of Asphalt Pavements.

1905.

SIDNEY WILLETT HOAG, Jr., B. S., M. Am. Soc. C. E., for paper entitled: The Dock Department and the New York Docks.

PAST PRESIDENT MEDALS.

NELSON PETER LEWIS	1903-4
SAMUEL CLARENCE THOMPSON	1905
GEORGE WILLIAM TILLSON	1906

INFORMATION.

Meetings.—Regular meetings are held in the Engineering Societies Building, No. 29 West 39th Street, Manhattan, on the fourth Wednesday of each month at 8:15 P. M., except in June, July and August. The annual Meeting is held on the fourth Wednesday in January.

Library.—The Society rooms and library are open every day and evening, including Sundays and holidays.

Members of the Society and all who feel an interest in the maintenance of a technical reference library, devoted more especially to the subject of municipal engineering, are asked to donate engineering books, reports, specifications, maps, plans, and photographs.

"Proceedings."—The Society issues one volume of *Proceedings* each year, usually in May. It contains all of the papers presented during the preceding year, the annual address of the President, the final reports of special committees on professional subjects, descriptions of the works visited by the Society, and the speeches delivered at the annual banquet which are of permanent value.

Proceedings are furnished without extra charge to members and are sold for $2.00 in cloth and $1.50 in paper. Exchanges are desired with other societies, libraries, colleges, etc.

Papers.—Papers and discussions on subjects of engineering interest are invited from all persons, whether members of the Society or not. They are, of course, subject to proper editorial supervision. All papers on their acceptance become the property of the Society.

Badges.—The badge of the Society is of gold with blue enamel in the design shown on the half-title of this book. It has a number only engraved upon the back and may be obtained as a pin, a watch charm, or a button. The price is $4.00. Application for it should be made to the Secretary.

Certificates of Membership.—The certificate of membership is steel-engraved on parchment paper, engrossed with the name of the member and the date of his election; the seal of the Society is impressed and it is signed by the President and Secretary. The size is 14 by 18 inches, and the price is $2.00. Application for it should be made to the Secretary.

Remittances.—All remittances should be made payable to the order of Municipal Engineers. They should be made by check on New York or by post-office or express money order payable at New York.

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FIRST VICE-PRESIDENT

GEORGE S. RICE.

SECOND VICE-PRESIDENT

ROBERT RIDGWAY.

SECRETARY

WISNER MARTIN.

TREASURER

ARTHUR S. TUTTLE.

DIRECTORS

Term expires January, 1907.

CHANDLER WITHINGTON,
HAROLD TAIT,
ROBERT R. CROWELL,
ELMORE F. AUSTEN (To fill vacancy),
ANDREW J. PROVOST, Jr. (To fill vacancy),
CLARENCE D. POLLOCK (To fill vacancy).

Term expires January, 1908.

HENRY R. ASSERSON,
BENJAMIN S. WEVER,
EDWARD A. BYRNE,
LLEWELLYN W. FREEMAN.

Term expires January, 1909.

MARTIN GAY,
HERMAN K ENDEMANN,
WILLIAM R. HILLYER,
EDWARD L. HARTMANN,
GEORGE R. OLNEY.

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The President is *ex officio* a member of all committees.

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SECRETARY

CLARENCE D. POLLOCK.

TREASURER

ARTHUR S. TUTTLE.

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Term expires January, 1908.

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EDWARD H. HOLDEN.

Term expires January, 1909.

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HERMAN K. ENDEMANN,
WILLIAM R. HILLYER,
EDWARD L. HARTMANN,
GEORGE R. OLNEY.

Term expires January, 1910.

WILLIAM D. LINTZ,
FREDERICK C. NOBLE,
ALBERTO SCHREINER,
CORNELIUS V. V. POWERS,
DANIEL D. JACKSON.

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The President is *ex officio* a member of all committees.

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PAST AND PRESENT OFFICERS.

Officers of the Society since its organization.

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NELSON P. LEWIS	1903-4
SAMUEL C. THOMPSON	1905
GEORGE W. TILLSON	1906
GEORGE S. RICE	1907

FIRST VICE-PRESIDENTS

OTHNIEL F. NICHOLS	1903
SAMUEL C. THOMPSON	1904
HENRY A. LA CHICOTTE	1905
GEORGE S. RICE	1906
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GEORGE W. TILLSON	1905
ROBERT RIDGWAY	1906
ROBERT R. CROWELL	1907

SECRETARY

WISNER MARTIN	1903-4-5-6
CLARENCE D. POLLOCK	1907

TREASURER

ARTHUR S. TUTTLE	1903-4-5-6-7

DIRECTORS

RUDOLPH HERING	1903
ROBERT RIDGWAY	1903-4-5
**WILLIAM S. DALRYMPLE*	1903-4
ROBERT R. CROWELL	1903-4-5-6
FREDERICK SKENE	1903
GEORGE S. RICE	1903-4-5
MAX RAYMOND	1903-4
HENRY R. ASSERSON	1903-4-5-6-7
BERNARD M. WAGNER	1903-4
THEODOR S. OXHOLM	1903-4
C. B. J. SNYDER	1903-4-5
JOHN C. WAIT	1903-4-5
EDWARD A. MILLER	1903-4-5
GEORGE W. TILLSON	1903-4
FREDERICK GREIFFENBERG	1903-4-5
CHANDLER WITHINGTON	1904-5-6
HAROLD TAIT	1904-5-6
BENJAMIN S. WEVER	1905-6-7

* *Deceased.*

EDWARD A. BYRNE	1905-6-7
LLEWELLYN W. FREEMAN	1905-6-7
ANDREW J. PROVOST, Jr.	1905-6
ELMORE F. AUSTEN	1905-6
MARTIN GAY	1906-7-8
HERMAN K. ENDEMANN	1906-7-8
WILLIAM R. HILLYER	1906-7-8
EDWARD L. HARTMANN	1906-7-8
GEORGE R. OLNEY	1906-7-8
CLARENCE D. POLLOCK	1906
WILLIAM D. LINTZ	1907-8-9
ALBERTO SCHREINER	1907-8-9
FREDERICK C. NOBLE	1907-8-9
CORNELIUS V. V. POWERS	1907-8-9
DANIEL D. JACKSON	1907-8-9
EDWARD H. HOLDEN	1907

BROOKLYN PUBLIC SERVICE TUNNEL.

INSPECTED BY THE SOCIETY MARCH 24TH, 1906.

The first work of interest inspected was the Public Service tunnel in Brooklyn. A large delegation of the Society assembled at Borough Hall and there amalgamated with a similar body from the Brooklyn Engineers' Club, who had, by chance, fixed upon the same day for the examination of this work.

The portion of the tunnel visited adjoins the East River Tunnel from the Battery to Joralemon Street. The construction is of the twin-brick-tubes type from Clinton to Court Street, and reinforced concrete from Court to Fulton Street, through Fulton Street to Flatbush Avenue and up Flatbush Avenue to the Long Island Railroad station. The brick tubes were first visited. They are built on the Meem system, in which the poling boards are advanced by means of hydraulic pressure and the excavation made beneath, and the timber is then placed. The invert is laid in the side trenches and carried around the circumference until the key is put in place. Mr. James C. Meem first introduced this system in work on the Chatham Square sewer in 1900. The tubes are about 60 ft. below the surface of the ground, and pass very close to numerous house foundations without material disturbance to them. From Court Street to the Long Island Railroad station the reinforcement of the concrete is done by means of square rods. It was interesting to notice the manner in which the elevated road and many houses and large stores were supported during the progress of the work. The contract called for a two and three-track construction, but it was, later, found desirable to provide for an extension and for an express service. It is therefore the intention to enlarge to four tracks. Altogether the afternoon proved a very pleasant and instructive one.

PENNSYLVANIA RAILROAD TUNNEL.

INSPECTED BY THE SOCIETY APRIL 28TH, 1906.

The second inspection was to the Long Island City end of the Pennsylvania Railroad tunnels under the East River. This trip was arranged through the courtesy of Mr. Alfred Noble, Chief Engineer of the Pennsylvania tunnels. A party of about thirty members was taken over the work by Mr. J. M. Hood, engineer for the contractors. Three very interesting hours were spent in the power house, at the air-locks and in the tunnels. The setting of the tunnel lining by the use of hydraulic jacks was one of the most interesting features of the day. The party enjoyed a most instructive and pleasant time, and those present must have appreciated the attention given them by Mr. Hood, and the patience with which he answered the endless questions prompted by the many novel features of the work.

NEW YORK CENTRAL TERMINAL IMPROVEMENTS.

INSPECTED BY THE SOCIETY OCTOBER 6TH, 1906.

The third inspection was to the New York Central Railroad Company's improvements above Forty-second Street. This work is being done by the O'Rourke Engineering Construction Company. A party numbering about fifty was fortunate in securing the personal services of Captain Erlandsen, Chief Engineer for the contractors and member of this Society. The work was inspected from Fifty-seventh Street to Forty-fourth Street, and included the following points of interest: the great retaining walls; the new buildings; the new bridge between Fifty-sixth and Fifty-seventh Streets; the underpinning of all buildings, particularly the Schaeffer Brewery; the power station, where the compressors were operated by electric motors, and where compressed air was piped to the various parts of the work; and the depression of the tracks to their new grade. Captain Erlandsen is entitled to the thanks of those present for an instructive and interesting afternoon.

CONCRETE SEA WALL, DEPARTMENT OF DOCKS AND FERRIES.

INSPECTED BY THE SOCIETY OCTOBER 20TH, 1906.

Special provision was made for this inspection by Chief Engineer Staniford, who arranged for the setting of one of the great concrete blocks for the sea wall.

The work was being done on the East River near the foot of Coenties Slip. The party was in personal charge of Engineer Moore, of the Department, who explained fully the methods of making the blocks, which weigh about 80 tons each. The manner of handling and setting the blocks was of great interest to those who had never inspected similar work. Owing to the wet and disagreeable day the attendance was small.

LACKAWANNA RAILROAD COMPANY IMPROVEMENTS.

INSPECTED BY THE SOCIETY NOVEMBER 27TH, 1906.

For this inspection about one hundred members of the Society assembled at the Lackawanna station at the foot of West Twenty-third Street, Manhattan, where they were met by Mr. Lincoln Bush, Chief Engineer of the Company; Mr. Snell, Superintendent of Buildings and Docks; Messrs. Murchison and Meize, heads of the architectural division, and Mr. Zippel, another of the officials of the Company, who had personal direction of the party. Great interest was shown in the fire-proof construction and general beauty and convenience of the Twenty-third Street terminal. The yards at Hoboken, the new terminal there, and the handsome steel train sheds are marvels of engineering and architectural skill and were greatly admired. The ventilating, heating and lighting appliances, in fact all of the details of construction, were closely scrutinized by the visitors, who freely commented upon the skill and thought

put into the work. After a delightful stop in Hoboken, the party boarded a special train, provided by the Company free of charge, and proceeded to Newark, where dinner had been ordered in advance. After dinner at the Continental Hotel, the inclined-plane at Roseville was inspected. This is a device for transporting boats on the Morris and Essex Canal over the Lackawanna tracks. It was found that the latter, when sunk to their new grade, would cut through the canal, so the water of the canal had to be siphoned under the roadbed, and the boats are now run into a cradle mounted on wheels, and carried over the tracks by cable and electric power. The party was then taken beyond Summit, New Jersey, around to the main line and back to the Kingsland shops. This plant, run by electric power, cannot be properly described here. It includes car-shops, carpenter, paint and upholstering shops and numerous other departments necessary to such an immense enterprise. The cleanliness of everything about the place was very apparent and the Company may well be congratulated upon the intelligent and effective management which creates and operates works of this nature. To the officials already named are due the gratitude of the Society for a delightful day and for the consideration shown the visitors. It was an inspection long to be remembered.

NEW YORK, NEW HAVEN & HARTFORD RAILROAD IMPROVEMENTS.

INSPECTED BY THE SOCIETY DECEMBER 15TH, 1906.

This trip was taken over the New York, New Haven & Hartford Railroad from One Hundred and Thirty-second Street to New Rochelle and return. Through the kindness of Mr. E. H. McHenry, Vice-President of the Company, and Mr. Edward Gagel, Chief Engineer, the Society was furnished a special train, free of charge. Both these gentlemen had signified their intention of accompanying the party, but, at the last moment, were detained at New Haven. However, Mr. W. B. Leonard and Mr. Camille Mazeau, member of this Society, represented these officials, ap-

parently to the complete satisfaction of the one hundred and twenty-five members who were present. Mr. Schuyler Hazzard, engineer for the contractors, also accompanied the party, and under the guidance of these three gentlemen a very full opportunity was given for an examination of the methods of raising track grades; the concrete retaining walls; the six-track construction across Pelham Bay; and the catenary construction at New Rochelle for the electrification of the road. The Committee has occasion to thank Mr. Mazeau for his assistance in securing the necessary facilities for the trip.

ANNUAL DINNER.

The Fourth Annual Dinner of the Society was held at Shanley's "Roman Court," January 9th, 1907. There were present 290 members and guests, which is by far the largest number ever gathered together, thus attesting both to the efficient work of the Banquet Committee and the growing popularity of this, the social event of the year. No formal speeches were announced, but several responses were made to the invitation of the toastmaster, Mr. George W. Tillson, President of the Society.

Hon. Herman A. Metz, Comptroller of the City of New York, spoke as follows:

"Mr. President and Gentlemen,—The last time I was in this room, up among the wax works, was at the Health Department Medical Inspectors banquet, and somebody also referred to the fact that a good tune would be "I've a Feeling for You," and then they sang "All I Get Is Sympathy." I am not suggesting any opinions at all, but I think it would be proper, in view of the fact that the President referred to the fact that the contractors provide us so much money for the work they are doing and know sometimes how long it takes to get it back, and I want to say it is the engineer's fault every time and not mine. If it were not for the engineer it would be some other fellow we would put it on, but it is not my fault; I always pay bills promptly—when I can sell the bonds.

"But, all joking aside, it is more than a joke to realize that they do put out money and then wait a long time to get it back very often, and it is no joke for them, although we can see the fun in it. If it were not for the engineers they would be happy, I think. Between the engineers and lawyers, though, I kind of come out ahead; the engineers offset what the lawyers do the other way, so between them they are two good professions to keep out of, as far as I am concerned.

"I was glad to be invited here to-night. I have got to leave you and go to a dinner up at the Athletic Club, but I wanted to come here because I had a thing in mind that I think is of general interest, but more especially to the engineers, and I wanted to speak

of it here first for the purpose of getting their co-operation. We see—I am speaking now of the average citizen—in the papers daily about the amount of money New York City is spending, blowing in, wasting, getting rid of in some way, but very few know just what we are getting for it or what is being done. Go anywheres. A few days ago I was on Long Island looking for new pumping stations. The average citizen goes to the faucet and turns it on and gets water, but don't know where it comes from or don't care. We build a tunnel and subway and the first thing he knows is we have a hole in the ground and he gets into it and don't know how it got there, who schemed it or devised it, or what it cost, or anything. Bridges, the big dam, the Croton Dam, monuments to the engineers of the city, and very few people know the first thing about them. There is nowhere they can find out; they don't read the *City Record;* it has not enough circulation and too much calculation, I guess, to make it of interest. They don't read the Comptroller's reports because they are three years late, and ancient history is not popular. But there is nowheres where the average citizen can go and find these things or see them without looking them up. Our civic bodies are self-constituted officials, who could not be elected constables, yet they want to run the city just the same. They know about these things through paid secretaries and they are the fellows who make all the trouble, or lots of it. They know where to go and then simply criticise; that is all they are for; you never hear them praise anything, but if there was some place where the average citizen could see, in a relief map, for instance, or even a model, or even a photograph, pictures of these things and get some idea of what is going on, or what we really have, I think it would change matters a good deal. I have taken up the matter with Dr. H. C. Bumpus, of the Museum of Natural History, and he said they would be glad to devote a room up there for a Municipal exhibit; cover the Aqueduct, the New Croton water-shed in a relief map; take up the Croton Dam; take up bridges; in fact, Municipal work of any kind or description; where we could get statistics and collect them, so we would have a central place where the public could go to, and I think it will be a great scheme. It would not cost anything; the Museum would provide it and would be glad to have it, and if you had one of such you

could get dozens of them. We could have one of them in Brooklyn at the Museum of Arts and Sciences. I think a thing of that sort would be of immense value to the city and people at large and I give it to you for what it is worth and ask your consideration of it in the various departments. I shall do all I can to help it along through my department. I am going to make an effort to collect from the various departments through the new Bureau just such statistics and make them available and I am going to ask every one of you to co-operate and if you have any suggestions in that line let me have them, because I think it is a good plan. I am glad of the opportunity to be here and speak of it here first and ask you to give it serious consideration. I thank you for the chance of telling you so."

HON. GEORGE CROMWELL, President of the Borough of Richmond, spoke in part as follows:

"Mr. Chairman and Fellow Municipal Engineers,—I had the great pleasure and honor of being your guest at the dinner two years ago and I want, for the pleasure and enjoyment that I had upon that occasion, to now return to you my most hearty thanks.

"At that time, if my memory serves me, I very confidentially advised you of some of the great advantages, the absolute superiority of the borough which I represent over all other parts of the city, and, knowing that even confidential remarks of that kind, made before so large a gathering as we had two years ago, will, to some extent, leak out, I thought it quite likely that at your meeting a year ago some reply might be made, and in order that every opportunity might be given to representatives of other parts of the city to make an absolute reply to what I said I stayed away last year. I understand that there was no reply, no Borough Presidents appeared to take up cudgels with me, and it is therefore the occasion of my coming back here to-night to tell you a few more things of similar nature, about which I have no doubt you would all, if you were on Staten Island, fully agree with me. I was very much surprised to find the entire Brooklyn representation of the Board of Estimate here, ready to reply, I suppose, or at least point out what secrets I had to reveal to you; and I therefore have been very much surprised to find this to be the fact.

"So I find, owing to the presence of this unexpected delegation from Brooklyn to listen to these confidential things that I was about to tell you about the Borough of Richmond and its great superiority over the rest of the city, I must confess I feel very much embarrassed in mentioning them and I am rather in doubt as to whether I should specify, but will simply generalize. I am one of those who believes that the future of the Borough of Richmond is really one of the greatest that the City of New York or this part of the country has before it. We have many of the most wonderful natural advantages, I think, that any part of the world ever had. I will not go into any of the details, but those of you who have been there realize how beautiful it is and how wonderful a place it will be, with the great centers of business population downtown; what a wonderful place it is for homes, and what a wonderful place for the city; what a wonderful development it has along the water front; what a wonderful chance here if Brother Coler extends his triquadruple line from The Bronx to the southern part of the city, carrying people for 5 cents. He and I really have agreed that we will press this route over into Richmond, and we will take the bulk of the population that will work in these great downtown sky-scrapers and we will say the best we can for Brooklyn as we pass by. He fully realizes this. He may say a few things in reply here; I see him taking notes here, but he realizes our superiority and he is already trying his best to steal away from us some of the best men we have in the borough because we realize that one of the great secrets of Richmond County's success has been due to the very excellent and splendid and high quality of the engineers we have had in charge of the work down there; and that is a secret that I am willing to state to you in the presence of even Mr. Coler. I think that our splendid work and our success is largely due to the fact that we have one of the best corps of engineers in any part of the city and I feel that the success of any great work depends upon the care and accuracy with which the work is originally planned and laid out and that is just what we are doing down in Richmond and I invite you to come down and see for yourselves and come down and help us along."

Hon. Bird S. Coler, President of the Borough of Brooklyn, lauded the work of his fellow Borough President Haffen, and

stated that the wonderful growth of the Bronx is due in large part to the personal supervision, the continuity of planning, the broad regard for the future which has always characterized him. He said in part:

"I would like to say just one word about the City of New York, which, to my mind, is the greatest city upon the face of God's earth. I will not touch on the moral side, because that is Metz's particular field, except to say that New York is a Sunday School compared with London, Paris, Berlin or Vienna. But politically in making this city we consolidated 90 separate corporations, and when that was done it was found we had a population almost equal to the population of the entire 13 Colonies at the time of the Revolutionary War. We found that the debt of the City of New York was more than the debt of all the States of the Union combined, and we found that the expenses of the City of New York at that time were one-seventh of those of the National Government itself. Since then, since the Spanish War, the National Government expenses have run up and they have not informed me just what they are, but at that time, when reigning in peace, the expenses of the City of New York were one-seventh of those of the National Government and we maintained a police which almost equaled an army of 7 000 or 8 000 men; at that time they only had 20 000 in the army of the National Government. We had firemen and street cleaners and a tremendous army of employees almost equal to that of the Government itself. And when I said that the debt of the City of New York was more than the debt of all the States in the Union combined, I only did that to impress the magnitude upon you, not to say anything about the credit of the City of New York. Some one has said—I think it was the Comptroller—that little was said about our assets. The City of New York owns real property to-day enough to pay its debt off three times over. The Dock Department alone pays interest upon practically $125 000 000 of our debt. Say the net debt is about $400 000 000; we have almost enough income paying property in the City of New York—the Rapid Transit, the Water-Works, and the Docks; the net income from those almost meet the interest obligations upon the entire debt of the City of New York. So a city in that position is upon a credit basis that is beyond that of any other city in the world. And then take your

engineering features. They talk about downtown being torn up and other sections of the city torn up. It is too much so in Brooklyn, but who is to blame for it? Someone said it was not you or it was not I. A portion of it is due, maybe, to our not getting the charter —which is an act not fully developed yet,—in such shape that we can act as quickly as we would, but the real reason is the tremendous growth of this great country of ours. We are building a new city upon an old city and then within a few years we are building a newer city upon a new city. That is what is the matter with the City of New York. Take below Fourteenth Street, where every water main that was laid through there for a city of 200 000 or 300 000 people and then the engineers and everyone thought they were outplanning the entire world, and to-day we have one building that will take more water and power than two or three entire blocks would at that time. We are having the most phenomenal growth that the world has ever seen. No city in the entire history of the development of this great world has progressed so rapidly—I will say that and say it feelingly; take the growth of Rome, Athens, London, Paris, all of centuries of growth, and here is a city that has more than 4 500 000 people, from 50 000 to 4 500 000 people in a hundred years. Those are the facts that we must get before the people."

John F. O'Rourke, of the O'Rourke Construction Company, eulogized the modern engineer as follows:

"Mr. Chairman, Fellow Engineers, Fellow Engineers who are not called Engineers, and all of us together:—It is very embarrassing to be introduced as the good contractor when, if you were my engineers, perhaps I would not be able to look you in the eyes and expect you to believe that.

"It is very difficult also to be called an orator and have you listen to me with patience.

"I therefore congratulate the Chairman of this dinner and the Dinner Committee that they had the wisdom not to tell me that I was expected to speak to-night. I attended a number of public dinners this winter and I must say that among those who were not expected to speak and who could not last very long as compared with those who were prepared to speak and lasted too long, the

Dinner Committees of the various dinners were to be congratulated upon the things that they should not have done; and the people at the dinner should have been commiserated on the things that they had.

"It is very lovely to be here among the Municipal Engineers. It is very lovely to think that you are, and I might even rise to the height of saying that I also am, a Municipal Engineer, although not under the dominion of the Comptroller in one respect. But it is a great thing to know that the City of New York has men such as it has in its service as engineers. It is even a splendid thing to see what I see to-night, the number of people at this dinner, and even the character of the people at this dinner and in greater numbers than there was even two years ago. I believe there are twice as many here to-night. Now, I am not president of any of the boroughs. There is actually nothing I can do except be pleasant to you to make your lot in life any happier. I cannot hold back your money and I can thank the Lord with great gratitude that you cannot hold back any of mine; so we are on a perfectly equal footing and when I listened to your eloquent Chairman introducing the gentlemen from two of our most important boroughs, omitting a couple more, and speaking of them as not like yourselves, I felt that if he gave me an opportunity I would have to differ with him. I would have to go back to the old definition of what the engineer was and then perhaps I could work in the borough presidents and the Comptroller and the editors and the contractors and all the rest, including the railroad men.

"As you know, the engineer is described in the Institution of Civil Engineers; also in the American Society of Civil Engineers; and he might be even described in the Society of Municipal Engineers—I trust he is—as one who utilizes the forces of nature for the use and convenience of man. Now, it is not necessary, I think, to go back to the good old days when the engineer was a man who knew hardly anybody, who got $100 a month and when there was anything to be shown or anything that would reflect any credit on anybody he was sent away on an errand, and the borough president or comptroller or editor or the railway magnate—possibly the latter mostly—would take his place and appear before the public as the thing of importance in the matter and the source of all the power

that was there. Now notice this: In that case this good, honest idealist, with the small wants, the shabby suit of clothes, was running mathematics through his head, he was running plans through his head, and ideas, he was building, he was the man with the mind, he was as true a poet—and I have always held that the engineer in the proper sense of poet is as great an idealist as the one described by one of our old (not very old) poets as "The Dreamer" —the man that lives alway; that was the engineer that was described by the man who defined the engineer and the man who defined the engineer did not know what he was defining simply because the engineer had not arrived at the point yet where he is what he is to-day. The engineer to-day is not merely he whose knowledge of mathematics is perfect, who knows all there is to know about strains and stresses and materials and the like, for if he be thus he simply prostitutes his talents; if he does not originate, if he does not create, he simply fulfills the duty of a clerk. The engineer, to my mind, is the man who utilizes the forces of nature for the use and convenience of man, and also for his edification and his education and that is the engineer, and he is the man that is a Comptroller like Mr. Metz, a Borough President like Mr. Cromwell or Mr. Coler; he is the man that utilizes the forces of nature, and they are not dead forces; they are forces that appeal to men; they are forces that control dead weight or live weight, as the case may be, and to-day an engineer who is confined only to the absolute technical application of mathematics and engineering is not an engineer in the proper sense of the word. I need only point to a few things.

"I am an engineer just the same as any of you. I have gone through the same things and to-day I am doing just the same kind of work. I get up as early in the morning and work as late at night and get dirt in my hair just as much as any of you, and make plans possibly as often as any of you do. But I am interested in the fact that I believe in the engineers; I believe this country to-day is what the engineers made it. I believe that the City of New York to-day is what the engineers make it and that it would stop to-day if the engineers stopped their work—except for something like this banquet.

"Now, take the case of the Pennsylvania Railroad. The Penn-

sylvania Railroad has just lost one of the greatest engineers that perhaps we know, or any of us have known, in Mr. Cassatt. In going through the subway I had a talk with Mr. Cassatt—the time they had that first trip—and he asked me what I thought about the cross-section of our Pennsylvania tunnel. I said that it was in my opinion extremely good, first-class engineering and I pointed out one or two things about it that struck me as not only good, but very original, and Mr. Cassatt beamed in a very pleasing way and said, 'That was my idea.' Now, I happen to know a little about it, and if it were not Mr. Cassatt's idea I would have known it before and when he told me it was his idea he simply told me what I knew, so I believed him.

"Now, what was Mr. Cassatt? Mr. Cassatt started in as a rodman on the Pennsylvania Railroad. Mr. Cassatt had ability; he had brains; he was a good engineer; he did his duty; he wronged no man; he cheated for no man; everybody was his friend, as they always are the friend of a man that is honest and fair and fearless, and that one quality of fearlessness is nothing more than honesty without self interest or meanness. Mr. Cassatt became President of that road; he made that road something that has never been dreamed of and never could have been dreamt of by the people who saw him as he rose up through it; but as a matter of fact he was rising when it was rising; it was the Pennsylvania Road and it rose because it had an engineer to follow it right through up to the top and take it beyond where anybody who was not an engineer could have taken it, and when it got to where it is, when it got to the point it might snap its fingers, so to speak, and say "To Hades" with the engineer; aren't we through with the engineers yet? I have heard that. But the Pennsylvania Railroad said, we will have another engineer and we will not only have another engineer, but have one like Mr. Cassatt, who started as a rodman, and there were several to choose from who were right up in the very top circle out of which the President would naturally be selected, so that, not only did they select a rodman who had risen to a point where he was eligible to be President of that road, but they could have taken a great many more men who had already done the same thing and were among the eligibles; in fact, there were no other eligibles than engineers for Presidency of the road.

"Now, what does that mean? It simply means this: That the engineer is the modern development of the highest type of man; taking man, not for what he may appear, what he would look in a picture, what he would be in a group, but take him as the man you want to do things, the man that is to control things, the man that is to think; that man thinks because he is educated to think, because he has got the power of combination, because he has been through the fire, he has been tempted and has lived through it; he has been scared and was not frightened (if you know what that is); and that is why those Municipal Engineers of to-day are much in the same position of eligibles as the group of great men who are at the top of the Pennsylvania Railroad was for its Presidency and it will not require somebody to come up here and explain why the people who are utilizing the forces of nature—and the forces of nature are moral and mental, they are technical, there are many forms in which the forces of nature must be taken, and those who can control those forces for the use and convenience of man consist of the engineer just as much as the fellow able to make a bridge which is going to stand dead weight or live weight—and that is why I started in to say that I consider that these gentlemen are engineers in the same sense we are, because they are controlling forces and doing things just as we are. But I only want to say to those gentlemen—it is not now, because we never could supplant them—but in time to come the City of New York will see its way clear to the same rule that the Pennsylvania Railroad has, having nobody but engineers to direct its work."

A. Prescott Folwell, Editor of the *Municipal Journal and Engineer,* spoke of the function of the editor and commended Comptroller Metz's plan of a publicity bureau. He said in part:

"Comptroller Metz has already brought to your attention one point that it had occurred to me to refer to and that had been brought to my attention in this way: At the very beginning of my editorial duties on the *Municipal Journal* I found that every large corporation had its Publicity Department; a man or a number of men or a staff of men whose business it was to see that the people at large were kept informed as to what they were doing; and it seemed to me that, as your Comptroller has said, this was just what

a city like New York needed, a Publicity Department, some Department, or it may not be, perhaps, some one Department, but some representatives among the various Departments, who should constitute themselves as practically a Publicity Department to inform the public what you are doing. I believe with him that it is only necessary for the people to know what is being done with the money to appreciate they are receiving their money's worth.

"I cannot claim all that the Chairman has said concerning me, that I have been successful in all branches of engineering, but I will say that I have been an engineer. I have carried a rod and chain and transit and one time I was a Municipal Engineer before the Civil Service was in effect and was the victim of machine politics, in which I had a rodman and chainman who used to show up about once a week and ask if his services were necessary. After the first week I concluded they were not and I learned how to chain, carrying both ends of the chain myself. I laid out a lock on the Erie Canal a good many years ago all alone. I found a good big brad-awl could hold the end of a chain just as well as a political chainman could; by sticking the brad-awl through the ring in the end of the steel tape and taking the other end of the steel tape I found it could chain just as well as he could.

"I also went into the contracting business a little. I have also been a Municipal Engineer, so that I know the difficulties under which a great many of you are laboring. I know what it is to have my pay held up as an engineer; I know what it is to have my money held up as a contractor and know what it is to hold it up as an engineer, and I can sympathize with you all.

"The engineer heretofore has been too much concerned with doing, it seems to me, and not enough with co-ordinating, we might say. He works in his own confines without paying enough attention to where they are going to overlap or touch some other department. It is, of course, true that a great many of you cannot, and it is impossible for you, in your capacity which you occupy, to take account of how your labor is affected by and affects the other Departments, but where, with a large city, the work is so vast as is indicated by the large number of engineers here present of the Greater New York, it is apparent that you must, to work to the best effect, take into account how this work is going to affect and be affected

by the other Departments; the Finance Department and the other Departments of the city.

"To return to the matter of the Publicity Department. I hope that the suggestion of the Comptroller will in some way be carried out. I am glad he brought in the name of my old friend, Mr. Bumpus. Mr. Bumpus was an old college friend of mine and if his enthusiasm has lasted until the present time and he receives the proper support in this matter he will do a good work for the City of New York in practically becoming the organizer of a Publicity Department for this great city; and I wish to second the Comptroller's suggestion and particularly request that something be done to educate the people to appreciate what is being done for them by you all.

"I thank you for your hospitality."

John F. Murray, Commissioner of Public Works, Borough of Bronx, spoke of the high regard in which engineers are held in his borough and felicitated the Society upon its great influence in everything pertaining to the material progress of the city.

The Society honored Charles Hayes Haswell, the oldest engineer in the world, by a rising toast.

Charles Warren Hunt, Secretary of the American Society of Civil Engineers, spoke a few words of graceful good-wishes.

George S. Rice, the newly elected President of the Society, was then introduced by the retiring President and pledged himself to do all that is within him for the growth, for the broadening of influence, for the development of high ideals of the Municipal Engineers.

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COLLEGE OF THE CITY OF NEW YORK

GEO. B. POST, ARCHITECT

METROPOLITAN MUSEUM OF ART
R. M. HUNT, ARCHITECT

110 AND 112 FIFTH AVENUE, NEW YORK
ROBERT MAYNICKE, ARCHITECT